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An International Journal

Official Organ of
The American Phytopathological Society

CONTENTS

Abstracts of papers presented at the twenty-fourth annual meeting of The American Phytopathological Society, Atlantic City, New Jersey, December 28 to 30, 1932, inclusive 1

Studies on certain environmental relations of the root-knot nematode, Heterodera radicicola.
G. H. Godfrey and Helene Morita Hoshino 41

Physalospora zeicola on corn and its taxonomic and host relationships ..... A. H. Eddins and R. K. Voorhees 63

Decay of wood and growth of some Hymenomycetes as affected by temperature ..... Ralph M. Lindgren 73

Transmissibility of the brooming disease of black locust.
L. W. R. Jackson and Carl Hartley 83

Knob and elevated vein formations on sweet-potato roots.
R. F. Poole 91

Crown gall on a conifer ..... J. G. Brown and M. M. Evans 97

Phytopathological Notes 103

The bulbous irises as hosts of Tylenchus dipsaci, the bulb or stem nema ..... G. Steiner and Edna M. Buhrer

Field inoculations of Pinus strobus with sporidia of Cronartium ribicola in Minnesota.
Ralph M. Lindgren and A. Dale Chapman

A disease of Colorado fir.
Alma M. Waterman and Malcolm A. McKenzie

Disease resistance in Allium fistulosum L. ..... E. L. Felix

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PAGE

ALLEN. Heterothallism in Puccinia graminis, P. coronata, and Melampsora lini 4

BEALE. Serologic reaction as a means of determining the concentration of tobacco-mosaic virus 4
BERG. A fruit spot associated with the papular type of apple measles 4
BIRKELAND. Electrophoretic studies on purified plant viruses 4
BIRKELAND. Experiments on acquired immunity in tobacco mosaic and spot necrosis 5
BLODGETT et al. Total amount of copper applied and ratio of lime to copper in Bordeaux as important factors in potato spraying 5
BRATLEY. Development of apple scab on stored fruit 5
BRIERLEY. Virus diseases of dahlia 6
BROOKS. A wilt of strawberry caused by Colletotrichum fragariae 6

CLAYTON. Relation of the toxin produced by Bacterium tabacum to the pathogenicity and host range of this organism 6
CONDIT and HORNE. A mosaic of the fig in California 7
COOK. Infection of seed clusters of spinach by Peronospora effusa 7
COOK. Pineapple leaf spot 7
CREAGER. Fusarium basal rot of bulbous iris 7

DAHL. Effect of temperature on brown patch of turf 8
DAVIS. Snow mold and brown patch caused by Sclerotium rhizodes 8
DICKSON and SHANDS. Disease-resistant wheats recently introduced from Russia 8
DICKSON, LINK, and DICKSON. Nature of resistance of corn to seedling blight 9
DIPPENAAR. Environment and seed treatment in relation to common potato scab 9
DRAYTON. Perfect stage of Sclerotium gladioli 9
DUFRÉNOY. Differentiation of green- and yellow-mosaic viruses in tobacco 10

EHRLICH. Nectria coccinea on beech 10
ELLIOTT and JOHNSON. Basal glume rot of barley 10

FARIS. Influence of soil moisture and soil temperature on infection of wheat by Urocystis tritici 10
FOLSOM. Effect of scab-preventive treatments on apple-tree growth and yield 11
FOLSOM. Potato tuber rot caused by Botrytis cinerea 11

GILGUT and BOYD. Cytospora canker of Picea 11
GREANEY. Method of estimating loss in yield 12
GREANEY and MACHACEK. Production of a white fertile saltant of Helminthosporium sativum by means of ultra-violet radiation 12
GUBA. Control of Alternaria dianthi causing a serious disease of the carnation 12
GUBA. Control of the root-knot nematode in greenhouses with carbon disulphide emulsion 13

HARTLEY. Damage to forest products by fungi 13
HARTLEY and JACKSON. A brooming disease of Robinia pseudoacacia 13

HATCH. Pure-culture technique for quantitative studies of plant growth in association with microorganisms 14
HATCH. True mycorrhizal fungus in contrast to Mycelium radicis atrovirens 14
HEIMBECK. Seed-borne bacteria main cause of pea wilt; Fusarium, Aphanomyces, and other organisms merely subsidiary 14
HENDERSON. Increasing the resistance of tobacco ring-spot virus to aging in vitro by use of carbolic acid 14
HEUBERGER and NORTON. Water loss in tomato mosaic 15
HOLBERT and FRYE. Bound water in leaf tissues of heat-resistance and heat-susceptible inbred strains of yellow-dent corn 15
HOLBERT, ELLIOTT, and KOEHLER. Bacterial leaf blight of dent corn 15
HOLTON. Differences in size and shape of smut balls of two physiologic forms of Tilletia tritici 16
HOLTON. Inheritance of chlamydospore characteristics in oat-smut fungi 16
HORSFALL and KERTESZ. Influence of root rot on peas 16
HUNGERFORD and REMSBERG. Sclerotium diseases of grains and grasses 17
HURT. Zinc hydroxide, a substitute for calcium hydroxide in arsenical sprays 17
HUTCHINS. Peach mosaic 17

IVANOFF. Bacterial wilt of corn 18

JACKSON. Effect of sulphuric acid and aluminum sulphate, as used for the control of damping-off of conifers, on soil pH 18
JACKSON. Effects of H-ion and aluminum-ion concentrations on conifer damping-off 18
JAGGER and CHANDLER. Physiologic forms of Bremia lactucae on lettuce 18
JOHNSON. Nature of injury caused by potato leaf hopper on forage legumes 19
JOHNSON. Cucumber mosaic on tobacco in Wisconsin 19
JOHNSTON and MILLER. Effect of leaf-rust infection on water economy and growth of two wheat varieties 19
JONES and RIKER. Two stem cankers of the China aster 20

KEUR. Seed transmission of the virus causing variegation of Abutilon 20

LAMBERT. Effect of carbon dioxide on cultivated mushrooms 20
LEDINGHAM. Life history, morphology, and cytology of Polymyxa graminis 20
LEHMAN. Bacterial twig and blossom blight of raspberry 21
LEVINE. Crown gall on Sahuaro (Carnegiea gigantea) 21
LIMING. Elm diseases in America 21

MACHACEK and GREANEY. Relation of mechanical injury to foot rot of cereals 22
MADER. Effect of pressure and amounts of copper applied in spraying potatoes 22
MADER. Evidence of stimulation of potatoes by Bordeaux mixture 22
MASSEY, WHITE, and JENKINS. Disease of cultivated sweet violet caused by Sphaceloma 22
MCCALLAN and WILCOXON. Form of toxicity surface for copper sulphate and for sulphur, in relation to conidia of Sclerotinia americana 23
MEIER, STEVENSON, and CHARLES. Spores in the upper air 23
MONTEITH, Jr. A Pythium disease of turf 23

NEAL and WESTER. An undescribed sclerotium fungus prevalent in northeast Texas 24
NEAL, WESTER, and GUNN. Morphology and life history of the cotton-root-rot fungus in Texas 24
NELSON and COCHRAN. Breeding Fusarium-yellows-resistant celery 25
NELSON and DOWN. Influence of pollen and ovule infection in seed transmission of bean mosaic 25
NEWTON and BROWN. Resistance of wheat and oats to stem rust 25
NEWTON, JOHNSON, and BROWN. Stripe rust in Canada 25
NORTON and HEUBERGER. Factors influencing type and sequence of tomato-mosaic leaf abnormalities 26

ORTON. Reaction of tissues from individual plants to soft-rot bacteria 26
ORTON and STANLEY. Serum-agglutination studies with soft-rot bacteria 27

PERSON. A bacterial blight of the broad bean in Louisiana 27
PIERSTORFF and LAMB. Dissemination of fire-blight bacteria by honeybees 27
PIRONE. Combating spinach damping-off by seed treatment 28
POOLE. The prevalence and relations of four soil-borne parasites on the peach trees in the Sand Hills of the Carolinas 28

QUANJER. A complex virosis of tobacco 28

RALEIGH. Fungicidal efficiency of a solution of mercuric chloride and potassium iodide 28
RALEIGH. A homemade colloidal copper spray 29
RIKER and HILDEBRAND. Seasonal development of hairy root, crown gall, and wound overgrowth on apple trees in the nursery 29
RIKER and JONES. Fusarium strains in relation to wilt of China aster 29
RIKER et al. Control of hairy root, crown gall, and other malformations at the unions of piece-root grafted apple trees 30
RODENHISER. The genetics of Sphacelotheca sorghi and S. cruenta 30
RODENHISER and BARNES. Pathogenicity of certain hybrids of covered and loose smuts of sorghum 30
RUTTLE-NEBEL. Comparative studies of field collections of Ustilago hordei and U. nuda 31

SANDERS. Notes on Bordeaux mixture 31
SCHULTZ and RALEIGH. A new necrotic virus disease of potatoes 32
SCHULTZ and RALEIGH. Resistance of potato to latent mosaic 32
SHAW. Resistance of rosaceous plants to fire blight 32
SHEAR and COOLEY. Relation of growth cycle and nutrition to perennial apple-canker infection 33
SLEETH. Relationship of Fusarium niveum to the formation of tyloses in melon plants 33
SPRAGUE. Association of Cercosporella foot rot with a specific ecological area 33
STAKMAN et al. Distribution of physiologic forms of Puccinia graminis tritici in relation to stem-rust epidemiology in 1932 34
STOVER and VERMILLION. Some experiments with a yellow mosaic of tomato 34

TAKAHASHI and RAWLINS. Evidence regarding the shape of tobacco-mosaic-virus particles 34
TAPKE. Comparative studies of two loose smuts of barley 35
TIMS. Stilbum cinnabarinum, the cause of a new fig disease in Louisiana 35
TULLIS. Leptosphaeria salvinii, the ascigerous stage of Sclerotium oryzae 35

VINSON. Further purification of the virus of tobacco mosaic 35

WALKER. Comparative studies of peas resistant and susceptible to Fusarium wilt 36
WALKER. Relation of soil fertility to incidence of Aphanomyces root rot of pea 36
WELCH. Nectria canker of basswood 36
WILCOX. Relation of cranberry varieties to the spread of false blossom 36
WILSON. Bacterial canker of Prunus spp. in California 36
WILSON. Development and control of olive knot 37
WILSON and RUNNELS. Influence of spray materials on transpiration 37
WILSON and TILFORD. Use of formaldehyde dust with vegetable seedlings 38
WINGARD. Nature of rust resistance in beans 38
WOODS. Intracellular bodies in ring spot 38

YOUNG. Sclerotinia stem canker of hollyhock 39
YOUNG. Soil infestation by chlamydospores of Tilletia levis in Montana 39

ZAUMEYER. Transmissibility of certain legume-mosaic viruses to bean 39
ZAUMEYER. Transmission of bean-mosaic virus by insects 40

Heterothallism in Puccinia graminis, P. coronata, and Melampsora lini. RUTH F. ALLEN.

Puccinia graminis and *P. coronata* are heterothallic. The isolated, unisexual infection makes good vegetative growth and produces active spermogonia and receptive hyphae, but the sporophyte is not initiated and aeciospores do not form. Only when spermatia of one sex are placed upon the surface of an infection of opposite sex or when adjoining infections of opposite sex become confluent does the normal development of aecia take place.

In *P. coronata* hyphae from vegetative mycelium, from spermogonia, and from aecial primordia grow out into stomata or between epidermal cells and serve to receive spermatial nuclei. In *P. graminis* formation of receptive hyphae is sharply limited by the tough epidermis of the barberry leaf. The spermogonia themselves serve as the main port of entry for spermatial nuclei.

Flax rust, *Melampsora lini,* also is heterothallic. The isolated infection bears no aeciospores. Fertilization may occur in infection from 8 to 20 days old, rarely older. Cells of the gametophytic, vegetative mycelium contain 1 to 4 nuclei. The young spermogonium centers on a stoma and at first uses the stomatal aperture as an ostiole. At this time no hyphae reach the surface of the leaf except at spermogonia. Cell fusions in the aecium occur regularly.

(Cooperative investigations, Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the California Agricultural Experiment Station.)

Serologic reaction as a means of determining the concentration of tobacco mosaic virus. HELEN PURDY BEALE.

Green-leaf extracts of Turkish tobacco affected with mosaic (Johnson's No. 1 virus) were tested for their ability to form precipitates when mixed with serum of rabbits hyperimmunized against homologus extracts. The concentration of active virus in each extract was then determined independently by the number of local lesions resulting from inoculation of *Nicotiana glutinosa,* according to the method of Holmes (Bot. Gaz. **87**: 39–55. 1929). A correlation was found to exist between the virus concentration of the various extracts and their ability to precipitate antiserums. It is suggested that the precipitin reaction may be of value for rapid and accurate determination of the relative concentration of virus extracts.

A fruit spot associated with the papular type of apple measles. ANTHONY BERG.

From several specimens of Grimes Golden apples bearing numerous circular, nearly black fruit spots, a fungus was isolated that in every respect resembles the fungus producing the papular type of "apple measles" on the wood. By artificial inoculations upon fruits of Rome, similar spots were produced, infection taking place through the lenticels. Although no inoculations on apple twigs have so far been made, it is pertinent that the infected fruits were collected by the Department of Botany, Purdue University Agricultural Experiment Station, in an orchard known to be infected with the papular type of apple measles.

Electrophoretic studies on purified plant viruses. J. M. BIRKELAND.

Our experiments indicate that the direction of migration of the viruses in an electric field is not altered by the state of purity nor the method of purification. The crude viruses of tobacco mosaic, spot necrosis, ring spot, and attenuated mosaic were found to migrate to the anode; that is, they behaved as though negatively charged. The same viruses, purified according to the methods described by Vinson and Petre and

by Brewer, Kraybill, and Gardner, also migrated to the anode. The purified preparations were biuret-negative.

Experiments on acquired immunity in tobacco mosaic and spot necrosis. J. M. BIRKELAND.

Results of our experiments indicate that *Nicotiana glutinosa* does not develop an acquired immunity from infection with the virus of tobacco mosaic or of spot necrosis. One series of plants was tested 4 weeks and another series 8 weeks after the initial infection. The test inoculation was made on new leaves and the number of local lesions were used as an indication of susceptibility. There was no significant difference in the number of lesions produced on the infected plants and on the controls. Plants infected with tobacco mosaic and tested with spot necrosis, as well as plants infected with spot necrosis and tested with tobacco mosaic, gave similar results. In some instances there seemed to be a greater amount of secondary necrosis around the primary lesion on the infected plants than on the controls.

Total amount of copper applied and ratio of lime to copper in Bordeaux as important factors in potato spraying. F. M. BLODGETT, E. O. MADER, O. D. BURKE, and R. B. MCCORMACK.

In potato-spraying experiments for 4 years at Pittsford, N. Y., on Rural New Yorker potatoes, there is strong evidence that the total amount of copper applied is an important factor in increasing yields of potatoes. Maximum yields were obtained by the application of from 70 to 90 lbs. of copper sulphate per acre per season in the form of Bordeaux, whether the variation was made by size or nozzle openings to apply more or fewer gallons per acre, by concentration of mixture, or by frequency of applications. At Riverhead and Sagaponack on Long Island, with Green Mountain potatoes the influence of the total amount of copper applied was not so marked and indicated that not over 40 to 50 lbs. per season are required to give maximum results.

In comparing Bordeaux mixtures made with different kinds of lime, that made with high magnesium lime has given slightly, but fairly consistently, better results than the mixture made with high calcium lime. As the magnesium is highly insoluble and inactive, the results seemed to indicate that a too high ratio of lime to copper was used. Field experiments in the 3 localities in the current season seem to confirm this explanation.

Development of apple scab on stored fruit. C. O. BRATLEY.

The demand for the present studies came as a result of frequent controversies regarding the responsibility for apparent increase of scab on commercially stored fruit. Experiments conducted during the past 5 years have shown that old lesions may enlarge and new ones appear on fruit while stored at 32° F., but that factors operative in the orchard are of more importance than those in storage.

Both enlargement of old lesions and development of new ones were favored by higher temperatures and humidities. Neither the use of different types of storage containers nor delay in storing fruit had any effect, except as the humidity and temperature were varied.

In some groups of scab-free fruit as many as 50 per cent of the apples developed new lesions during storage. Fruit picked after a wet fall from poorly sprayed, heavily infected trees was particularly susceptible.

All attempts to obtain spread from scabby to clean fruit in storage were unsuccessful, as were also inoculations attempted during picking and packing.

Virus diseases of dahlia. PHILIP BRIERLEY.

Dahlia mosaic is prevalent in New York, New Jersey, Connecticut, and probably throughout the United States. The most characteristic symptom is vein banding. Some dahlia varieties show no appreciable dwarfing or distortion when affected. Others show marked dwarfing, various forms of leaf distortion, or vein necrosis. The mosaic virus from varieties of diverse symptom types produces uniform symptoms in a given variety. The virus has been transmitted by grafting and by *Myzus persicae*, not by mechanical methods nor through seed. The incubation period is usually 4 to 6 weeks.

Dahlia ring spot is characterized by zigzag or ring markings in shades of green, later becoming necrotic. Ring spot has been transmitted, usually together with mosaic, by grafting and is not certainly distinct from mosaic. Yellow ring spot, seen only in stock from Utah, appears as yellow zigzag or ring patterns. Transmitted by grafting, but not by mechanical methods, this virus produces symptoms distinct from mosaic on two varieties. An oak-leaf pattern, apparently of virus origin, is distinct from all the above symptom types on one variety and distinct from mosaic in a second.

A wilt of strawberry caused by Colletotrichum fragariae. A. N. BROOKS.

A sudden wilt of strawberry plants has been observed in the summers 1930–32 in the central Florida area, both in the nurseries and in plants set in the fields. The young leaves of affected plants wilt suddenly, and the crowns show the presence of a reddish brown dry rot in pith and cortex. The rot usually starts in the old runner stub at the base of the crown and progresses in both directions, extending to the bud and portions of the roots near the crown. At higher temperatures the disease kills the plants, while at lower temperatures the progress of the rot is so retarded that the plants are able to survive by putting out adventitious roots above the rotted portion of crown.

The disease has been found associated with anthracnose or runner spot caused by *Colletotrichum fragariae*, and this parasite has been isolated from the centers of rotted crowns and from diseased roots. The ability of this organism to produce the wilt has been proved by artificial inoculations. Incubation periods vary from 2 days at 35° C. to more than 26 days at 15° C.

Relation of the toxin produced by Bacterium tabacum to the pathogenicity and host range of this organism. E. E. CLAYTON.

Bacterium tabacum secretes a powerful exotoxin, which destroys chlorophyl and so causes the characteristic "wildfire" leaf symptoms. This toxin, while comparable in activity to the toxin produced by animal pathogens, differs from them in its properties. It is heat-stable and is not precipitated by mercuric chloride, neutral calcium acetate, or neutral lead acetate. It is not removed from solution by charcoal and passes through Berkefeld, collodium, and cellulose filters. It is not affected by acids but is quickly inactivated by dilute sodium or potassium hydroxide. Leaf-prick inoculations with (a) toxin, (b) toxin and bacteria, and (c) bacteria gave from (a) and (b) typical wildfire symptoms with many species of plants; but from (c) consistent positive results were secured only with Nicotiana species. The toxin inoculations demonstrated that tobacco-leaf tissues are no more susceptible to injury from this agency than tomato or eggplant and distinctly less so than bean or cucumber. The toxin-plus-bacteria inoculations showed that the bacteria will persist for some time in the tissues of all of the above plants from which they can be reisolated and their pathogenicity demonstrated. Field inoculations resulted in heavy infection plus subsequent disease spread in the case of tobacco and occasional lesions without subsequent disease spread in the case of other crops.

A mosaic of the fig in California. IRA J. CONDIT and WM. T. HORNE.

A mosaic-like trouble of fig leaves has long been recognized in California. It may almost be said that every fig tree in the State shows traces of mosaic, though the disease is not generally regarded as commercially important. The meagre literature referring to it is discussed and a description of the symptoms is given. Areas of lighter tissue occur and leaves may be distorted. Both leaves and fruits are affected and in severe cases may drop. Studies are reported on the comparative susceptibility of varieties. Aside from blastophaga, *Blastophaga psenes*, and visitors to the ripe fruit, the insect population on figs is comparatively small. Aphids and thrips are present for brief periods, while the fig mite, *Eriophyes ficii*, is abundant and widely distributed. A mosaic vector has not been found.

Cuttings from mosaic-affected trees propagated in the greenhouse continue to show mosaic. Seedlings from affected plants have remained healthy for about a year in the greenhouse, whereas buds from healthy seedlings set in diseased trees have grown into mosaic-affected shoots. Seedlings several years in the orchard show much mosaic. The trouble under consideration is apparently a true mosaic.

Infection of seed clusters of spinach by Peronospora effusa. HAROLD T. COOK.

The conidia and conidiophores of *Peronospora effusa* were found on the fruit (seed clusters) of spinach seed plants at the Virginia Truck Experiment Station in 1930 and 1932. Sections of the infected fruit showed that the mycelium of the fungus had permeated the pericarp, funiculus, and the integuments of the ovule. The mycelium was not found in either the embryo or perisperm. Oospores were not found in any of the seeds that were sectioned, but they were found in abundance in infected leaves on the same plants. The occurrence of infected seed may afford one means by which *P. effusa* is introduced into new fields or areas.

Pineapple leaf spot. MELVILLE T. COOK.

This disease was described by Larsen of Hawaii in 1910, who attributed it to *Thielaviopsis paradoxa* that entered the plant through punctures made by spines and insects. The disease was most severe in cloudy, moist weather. Similar spots on pineapple leaves in Puerto Rico and other of the West Indies have been attributed to the same cause, apparently without careful study. An outbreak of this disease in Puerto Rico during the past summer was studied by the writer, who failed to find *T. paradoxa* or any other organism in the spots, which were evidently due to weather conditions. The disease develops during wet, cloudy weather and subsides during dry, clear weather. It was more severe on limestone soils than on volcanic soils. Microscopic examination showed the cells in the infected areas black and collapsed. The writer does not question the results obtained in Hawaii, but certainly the fungus is not necessary for the disease in Puerto Rico.

Fusarium basal rot of bulbous iris. DON B. CREAGER.

A Fusarium root and bulb rot of Spanish and Dutch iris was first observed by the writer in the summer of 1929 on Long Island, N. Y. The disease is very destructive to a number of commercial varieties, including Cajanus, Hart Nebrig, and Imperator. The pathogen enters the roots and finally involves the basal plate and scales of the bulb. It is a species of Fusarium of the *Elegans* type closely resembling *Fusarium oxysporum*. Its pathogenicity has been established as a result of inoculations of healthy bulbs in moist chambers and by growing healthy susceptible varieties in artificially infested soil. Preplanting dips with certain fungicides have given fair control in trial tests.

Effect of temperature on brown patch of turf. ARNOLD S. DAHL.

Analysis of five summers' temperature records at the Arlington turf garden, Rosslyn, Va., showed that the occurrence of brown patch caused by *Rhizoctonia solani* varied directly with the temperature. A period of low temperature was not necessary for the fungus to become active. The disease occurred 82 per cent of the days that the minimum temperature was above 21° C. The germination of sclerotia of several strains of *R. solani* obtained from different sources was studied in Petri-dish cultures on potato-dextrose agar at temperatures from 8° C. to 40° C. in 4° intervals. The time interval required for germination at each temperature was recorded. There was some variation between the different strains in response to temperature. Some strains germinated at 8°, others did not, but all germinated at 12°. The shortest period of germination occurred at 28° or 32°, and all strains germinated at 36° but none at 40°. The sclerotia did not require any drop in temperature to facilitate germination and did not germinate so quickly in most cases when the temperature was temporarily lowered as when it was kept constant. Chilling the germinating sclerotia did not increase the amount of mycelial growth except when the cultures were kept at the unfavorable temperature of 36° C. before and after chilling.

Snow mold and brown patch caused by Sclerotium rhizodes. W. H. DAVIS.

Snow mold and brown patch were observed extensively on golf greens, lawns, and meadows in New England. Snow mold generally formed during the thawing of deep snow of long standing; brown patches were caused by the mycelium from germinated snow-mold sclerotia, and a "silver tip" resulted from inoculations of overwintering leaf tips by mycelium associated with snow mold and brown patch.

Specimens of snow mold were received from 54 stations in 15 States distributed in eastern United States as far south as Virginia; west to Idaho; north to Orono, Me.; also, from Ottawa and the Canadian Rockies in Canada.

There were two types of snow mold, the sclerotial and the non sclerotial. This study is limited to the sclerotial type.

Turfs established by planting rhizomes with sclerotia of snow mold attached became infected with brown patch. An average of 175 sclerotia were formed on rhizomes over each square inch of one brown patch. In the field, sclerotia germinated after a rest period varying from 2 to 12 months; under laboratory conditions, when stored dry, 3 months to 2 years; from leaves showing silver tip, 9 months to 4 years, with a maximum viability of 9 years.

The mycelium of the fungus was of two types; nonpathogenic or sclerotia-forming; pathogenic or of sclerotial origin.

Disease-resistant wheats recently introduced from Russia. JAMES G. DICKSON and R. G. SHANDS.

Triticum persicum var. *stramineum* and *T. timophavii*, obtained from the collection of Dr. N. I. Vavilov, have shown resistance to *Puccinia triticina*, *P. graminis tritici*, and *Erysiphe graminis* and have produced fertile hybrids with the common varieties of *T. vulgare*. *Triticum persicum* var. *stramineum* has shown greater stability in resistance and varietal characteristics and has proved more suitable agronomically than other varieties tested. *Triticum timophavii* has been immune from rusts in 2 years' field tests and only slightly susceptible to *E. graminis* during the later stages of plant development when the floral structures were slightly mildewed. This species was fairly resistant to scab in 1 year's test. The F_1 generations from crosses of *T. vulgare* with both the Russian species have been intermediate or susceptible to leaf rust. (Cooperative investigations between

the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Wisconsin Agricultural Experiment Station).

Nature of resistance of corn to seedling blight. JAMES G. DICKSON, KARL P. LINK, and A. D. DICKSON.

Previous investigations have shown differences in chemical composition generally correlated with maturity of seedling tissues, especially the cortical structures. The rapidly maturing tissues in the resistant seedlings seemingly prevent advance of the fungus and furnish an unfavorable nutritive substrate for the parasite. Embryonic structures in the resistant seedlings have shown a much higher acidity than similar regions in the susceptible plants. The presence of polyuronides, principally polyglucuronides, have been found correlated with the high acidity in these tissues. The resistant seedlings grown at 12°–16° C. contained approximately 20 per cent more uronic acids than susceptible seedlings. Dilute solutions of the uncombined acids gave a pH of 2.5–3.0 and reduced fungus growth when added in low concentrations to the culture solutions. The calcium salts of the acids were much less active in inhibiting fungus growth. (Cooperative investigations between the Wisconsin Agricultural Experiment Station and the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture).

Environment and seed treatment in relation to common potato scab. B. J. DIPPENAAR.

The combined relation of soil moisture and soil temperature to the development of common potato scab was studied in the Wisconsin soil-temperature tanks. At each of 5 temperature stages between 13° and 25° C., inclusive, scab development was greatest at 40 per cent of the water-holding capacity of the soil used, successively decreasing at 55, 70, and 85 per cent. Little or no scab developed at 70 per cent of the water-holding capacity or above, while relatively few or no tubers grown at 55 per cent or below were free from scab. Temperature in the same experiments was less important than soil moisture; bad to severe scab developed at each of the temperatures with the same low soil moisture. Both scab and tuber development in these experiments seemed to be best at about 17° C. Simliar results were obtained in experiments in which the temperature fluctuated.

Both 5- and 10-minute treatments of very scabby seed potatoes in acidulated mercuric chloride (02 per cent $HgCL_2$ + 1 per cent HCL) gave as good results against scab as the standard treatments in corrosive sublimate or cold formaldehyde. In the same experiments, however, acidulated mercuric chloride was the most effective against Rhizoctonia.

Perfect stage of Sclerotium gladioli. F. L. DRAYTON.

This fungus was described as the cause of the dry-rot disease of gladioli. Since then, other genera of the Iridaceae have been added to the suspect range, *viz.*, Crocus, Freesia, Tritonia (Montbretia), and Lapeironsia (Anomatheca).

No sexually produced fruiting bodies of this fungus have yet been observed in nature, but the discovery of the sexual function of its microconidia has made it possible to obtain apothecia in artificial cultures as a result of reciprocal crosses between compatible isolates. In these crosses microconidia are applied to receptive structures developed on a stroma.

The apothecia are typical of those found in Sclerotinia. The fungus is, therefore, transferred to this genus under the name *Sclerotinia gladioli* (Massey), n. comb.

Differentiation of green- and yellow-mosaic viruses in tobacco. J. DUFRÉNOY.

Confirming McKinney's results on the complex nature of viruses, it was observed that juice from yellow areas of mosaic-tobacco leaves (as obtained from the field) produced local "yellow" areas where inoculated into mature leaves of tobacco. The cells showed degeneration of plastids, and the cytoplasm, near the nucleus, assumed the pattern of a network of threads, enmeshing a number of small vacuoles where phenolic compounds became abundant.

Leaves developing from upper buds a few weeks after inoculation of lower leaves show typical mosaic (cells showing striated and plate bodies).

The juice from "pale green" areas of mosaic leaves produce no local lesion where inoculated but induce typical green mosaic in leaves subsequently developing from buds.

Nectria coccinea on beech. JOHN EHRLICH.

A menacing disease is resulting in wide-spread mortality to the beech, *Fagus grandifolia,* stands of the Canadian Maritime Provinces. A survey of the affected regions disclosed that approximately 90 per cent of the beeches over 3 in. d.b.h. in forest stands are infected and that approximately 50 per cent are already dead where attack has continued for several years. The disease was caused by *Nectria coccinea,* following attacks by the beech scale, *Cryptococcus fagi.* Field observations, inoculations and other experiments, and histological studies showed that the fungus enters the minutely fissured periderm of trunk and branches where the insect has been feeding and grows rapidly through bark, phloem, cambium, and peripheral sapwood. Death of these tissues and interruption of conduction result. Both fungus and insect are disseminated by wind, the fungal spores during and after rain and the insect during egg and larval stages in summer and autumn. The fungus is advancing southward and westward and has just been found in Maine. The insect already occurs as far south as Boston, Mass. Control lies in protection against or eradication of the insect, which is practicable with ornamental trees, and in the possibility of forest management planned to minimize the severity of attack.

Basal glume rot of barley. CHARLOTTE ELLIOTT and A. G. JOHNSON.

In 1931, typical specimens of basal glume rot of wheat were received from Arkansas. Along with these were specimens of barley heads with some of the kernels showing characteristic, dull brownish black bases, which symptoms suggested basal glume rot. The discolored areas were teeming with bacteria. Isolations from both wheat and barley specimens yielded similar organisms both of which were identified as *Bacterium atrofaciens.*

Inoculations with the organism isolated from wheat reproduced the characteristic symptoms on wheat and barley and from these lesions the typical white organism was reisolated. The organism isolated from barley produced blackening at the bases of spikelets of both wheat and barley, from which pure cultures of the white organism were reisolated. Reisolations of the wheat organism from barley again produced typical discoloration on heads of wheat and barley.

Influence of soil moisture and soil temperature on infection of wheat by Urocystis tritici. J. A. FARIS.

Experiments, in which Harvest Queen wheat was inoculated with flag-smut spores and germinated under controlled conditions of temperature and moisture, indicate that high infection may be secured over a relatively wide range of temperature (10° to 20° C.) when the soil is rather dry during the period of the germination of the wheat.

When the soil moisture was at 40 per cent, that is, at about the point considered ideal for sowing wheat, high infection was secured only when the wheat was germinated at temperatures of 10° and 15° C.

When the soil was almost saturated (60 per cent), high infection was secured at 10° C. Infection percentages dropped very rapidly at temperatures higher or lower than this.

Effect of scab-preventive treatments on apple-tree growth and yield. DONALD FOLSOM.

In a young McIntosh apple orchard in Maine, 350 trees were studied for 5 years in 45 replicated plots. Four series, respectively, received sulphur dry mix, sulphur dust, lead arsenate, and dry lime sulphur during this period and produced average stem diameters of 41, 40, 39, and 38 mm. A fifth series, receiving flotation sulphur 3 years and nothing 2 years, grew to 38 mm. The diameter differences here were not significant statistically and were much less than the generally significant stem-diameter differences found with several natural modifications of the soil, a sandy loam. In an adjacent older McIntosh orchard in 28 comparisons, each involving a series of trees treated with unmodified dry lime sulphur, this material generally tended to increase rather than decrease fruit yield and had no effect on rate of girth increase. Here, in 20 comparisons, using individual-tree data, there generally was no significant correlation between leaf scab, leaf-spray injury, yield, and growth within the same season, while further correlations showed an interpedendence of fast growth, earliness of first yield, and the yield rate for a period of recent years.

Potato tuber rot caused by Botrytis cinerea. DONALD FOLSOM.

Botrytis cinerea was readily isolated in different seasons from a rot of potato tubers stored in Maine. In this type of rot the skin becomes wrinkled, while the flesh easily loses water under pressure. Where advancing rapidly, the rot causes a temporary darkening of the flesh. Different cultures of the fungus, including some isolated from potato foliage and stems during an epidemic of Botrytis blight in the field, have, under certain conditions, caused the same kind of rot as that found in storage. A different form of rot also has been obtained under certain other conditions, where all inoculations have been successful but where the lesion did not penetrate more than 1 or 2 cm. deep. The fungus has been reisolated, reinoculated, and again reisolated, without particular difficulty except where conditions were very favorable for wound repair.

Cytospora canker of Picea spp. C. J. GILGUT and O. C. BOYD.

For many years the dying of lower limbs of blue spruce, *Picea pungens glauca*, and to less extent Norway spruce, *P. excelsa*, has been observed in Massachusetts. In 1923 a limb canker of unknown cause was reported on *P.* sp. from Connecticut. In 1930 a species of Cytospora was found constantly associated with spruce cankers in Massachusetts. The same year, *C.* sp. was reported from New Jersey on *P. pungens kosteri*.

Cytospora limb canker on blue spruce is wide-spread in Massachusetts and frequently involves from $\frac{1}{4}$ to $\frac{1}{2}$ of the limbs. The disease attacks smaller branches, as well as larger limbs, but trunk infection has not been observed. It usually starts on a lower limb and spreads upward and laterally. There is pronounced gummosis in most cases but rarely, if ever, any hypertrophy or atrophy. No organism other than Cytospora has been found in the cankers.

Spring inoculations with pure cultures of Cytospora from blue spruce produced typical limb cankers by fall, with pycnidial formation, gummosis, and death of limbs, on both blue and Norway spruces. Reisolations yielded the same organism in pure culture.

Method of estimating loss in yield from cereal diseases. F. J. GREANEY.

During the past 8 years, field experiments have been made each season to determine the value of sulphur dusting for the control of cereal rusts. The data accruing from experiments, in which the amounts of disease on individual plots were varied by sulphur dustings at different rates and intervals, were used to estimate the loss in yield due to stem rust, *Puccinia graminis.*

The method employed has been that of correlating rust percentage and yield in a single standard variety. Each year the results were summarized in the form of correlation coefficients and regression equations. When the correlation coefficients obtained were statistically significant it was found that the regression of yield on percentage rust was linear, indicating that uniform increases in rust result in uniform reductions in yield. It was possible, then, to determine the reduction in yield for each 10 per cent of stem rust. The value thus obtained was used in calculating the annual loss from stem rust in Manitoba. The method has been used also to estimate the loss in grain quality from rusts and from some of the minor diseases of cereals.

Production of a white fertile saltant of Helminthosporium sativum by means of ultra-violet radiation. F. J. GREANEY and J. E. MACHACEK.

Preliminary studies on the effect of ultra-violet light on growth and saltation in *Helminthosporium sativum* have shown that some of the strains of this fungus were apparently unaffected by the rays, but the majority produced sector and internal saltants. The saltants, so far, have remained constant. In addition to a decided increase in the frequency of saltation, irradiation produced a marked suppression of growth in those strains affected by the rays.

One strain of *H. sativum* irradiated with ultra-violet light produced a strongly sporulating, albinistic saltant. The spores and mycelium of the saltant are hyaline but, in mass, pale pink. Pathogenicity studies in greenhouse and field have shown it to be as virulent as the parent. It has been recovered unchanged from the diseased plant parts. The problem of fixing the taxonomic position of this new fungus presents some difficulty.

Control of Alternaria dianthi causing a serious disease of the carnation. E. F. GUBA.

Wide differences exist in the reaction of carnation varieties to infection. The disease is of consequence only on plants grown in the field and is occasionally destructive in the cutting beds and in the flats.

Dipping the cuttings in 1–1,000 solution of potassium permanganate for 5 minutes greatly improved rooting and helped to control the disease in the cutting bench.

Laboratory experiments reveal the superior toxicity of Bordeaux 4–4–50 and calcium arsenate 1–50 to the conidia. Bordeaux and calcium arsenate with ½ pt. of linseed oil was the most efficient fungicide in the field. The use of Bordeaux on benched plants in the fall added to the control of the disease.

Benching field-grown plants by the first week in July was the most effective control measure. The age of the plants has an influence upon the prevalence of disease.

Naphthalene fumigation in comparison with syringing with water, for controlling the red-spider mite, indirectly lessened the amount of disease and increased the number of blooms. A spray containing 5 per cent salt and 0.2 per cent nicotine sulphate, which is occasionally used for mite control, was not toxic to the conidia and was shown to increase the hazard from the disease.

Control of the root-knot nematode in greenhouses with carbon disulphide emulsion. E. F. GUBA.

Greenhouse soil treatments with carbon disulphide emulsion have given good control of the root-knot nematode, *Heterodera radicicola*, and have restored normal yields of tomatoes. A stock emulsion containing 68 per cent carbon disulphide, 26 per cent water, and 6 per cent resin-fish-oil soap, diluted in water to make a 1–50 concentration, was applied at the rate of 1 gal. per sq ft. of bed. The cost for materials is approximately 9/10 of 1 ct. per sq. ft. The addition of 2/3 gal. of formaldehyde to the above formula is required to control fungous pathogens and weeds, at an additional cost of approximately 7/10 of 1 ct. per sq. ft.

The removal of the large infested roots when the old vines are cleaned out, a lapse of 2 to 3 weeks to permit decay of root material, and thoroughness of application add to the efficiency of this chemical treatment. A further delay of 1 week after treatment is necessary before planting.

Carbon disulphide emulsion should find particular use in greenhouses not equipped for efficient steam or hot-water sterilization or where it may be more practicable and desirable to use this chemical, and it should encourage a more general use of formaldehyde for controlling fungous pathogens.

Damage to forest products by fungi. CARL HARTLEY.

The financial losses due to the deterioration of forest products are much larger than those caused by equal amounts of deterioration in the living tree. In meeting timber shortage, pathologists can give more immediate help through decreasing the drain due to forest-products fungi than by developing methods for combating diseases of the standing forest. Fungi that cause discoloration are of increasing importance because the sapwood they attack forms an increasing proportion of the lumber we use. New antiseptics, including ethyl mercury compounds and chlorinated phenolates, have been found to give lumber a high degree of protection during the seasoning period at costs for materials little over ½ ct. per 100 sq. ft. of surface protected. Decay is much more important than stain. Various estimates have placed the amount of timber that goes annually to replace destroyed material at between 1/6 and 1/12 of the total cut. Even the lowest estimate, when applied to saw timber, is equal to 41 per cent of the estimated annual growth of such material in the forests of the country. An increasing proportion of the timber in use in exposed situations is protected by preservatives, but recent architectural styles favor decay in frame buildings.

A brooming disease of Robinia pseudoacacia transmitted by grafts. CARL HARTLEY and L. W. R. JACKSON.

The disease is common on sprouts in the Middle Atlantic States. Aside from the conspicuous witches' brooms, no definite symptom has been recognized. Few large trees have been found with visible disease in the tops, and only one showed the burls mentioned in a previous paper. Broom production occurs mainly during late summer. Perhaps because of the abnormally late growth, broomed portions of crowns ordinarily die during the following winter. A root may continue to produce broomed sprouts year after year without signs of abnormal growth in the crown of the tree to which it belongs. An infected tree may to all appearances entirely recover, but trees not noticeably abnormal sometimes send up many broomed sprouts from the trunk after they are cut. It is possible that part of the dying back of the locusts in some localities, without brooming of the crowns, is due to this disease in the roots. A Camarosporium found frequently associated with the disease is not believed concerned in causing it. Graft transmissibility is demonstrated in a paper to appear in an early number of Phytopathology.

Pure-culture technique for quantitative studies of plant growth in association with microorganisms. A. B. HATCH.

An apparatus devised possesses none of the undesirable environmental limitations inherent to ordinary pure-culture methods. It exhibits qualities of environment that are comparable to those that exist in open sand cultures placed in an artificially cooled and dehumidified greenhouse. The plant chamber consists of a copper base, containing a Pyrex jar for sand and supporting an inverted Pyrex jar that is sealed to the base with De Khotinsky cement during sterilization. A continuous stream of sterile air passes into the chamber through a large diatomaceous filter. Sterile nutrient is introduced and removed through a Pyrex tube that extends to the bottom of the sand container end that is bacteriologically sealed at the open end (Doak's technique). The chambers are housed in a small air-cooled compartment of a greenhouse. The culture method permits: (1) complete change of nutrient at frequent intervals; (2) maintenence of an atmosphere of normal composition, humidity, and temperature; (3) direct solar irradiation (through glass); and (4) the growing of tree seedlings in quantity. A wide range of Pyrex jars is available with which chambers may be constructed in sizes suitable for most agricultural crop plants.

True mycorrhizal fungus in contrast to Mycelium radicis atrovirens. A. B. HATCH.

A fungus with black mycelium was isolated from black mycorrhiza of *Pinus sylvestris* growing in Sweden. It is provisionally named *Mycelium radicis nigrostrigosum.* In pure culture with *P. strobus* and *P. resinosa* it formed typical ectotrophic mycorrhiza. Mycelium of the *M. resinosa atrovirens* type, isolated from the same type of mycorrhiza on *P. sylvestris,* overgrew and killed similar pure-culture seedlings. The latter fungus in aerated culture neither attacked the aerial portion of the seedlings nor formed mycorrhiza. It apparently exhibits maximum development on the surface of short roots that have been converted to mycorrhiza by other fungi.

Seed-borne bacteria main cause of pea wilt; Fusarium, Aphanomyces, and other organisms merely subsidiary. LOUISE SOLBERG HEIMBECK.

Pea wilt is best studied on peas grown in water cultures, *i.e.,* Rothamsted solution, as fatty substances then oxidize slowly, so that the cell walls of the roots are easily penetrated by the bacteria, which attack primarily meristematic tissues just becoming differentiated. Root tips are discolored and stop growing. Entrance to the vascular core is chiefly forced through endodermal openings formed by secondary rootlets. The host cells react by coating the intruders with a yellow brown reddish gum-like substance, in which the bacteria lose their identity for a microscopical observer. Stained microtome sections of attacked plants from water cultures, however, disclose the bacteria.

Once inside the translocation system, the bacteria may reach the growing pod and enter the ovule, which, nevertheless, may develop into a viable seed. Seedlings originating from infected seed show vascular discolorations in the cotyledon petioles, in epicotyl, or root. Under good growing conditions they may develop into apparently healthy seed-bearing plants, if cold wet weather or attacks of subsidiary parasites do not so lower their vitality that the bacteria get the upper hand and the plants wilt. Besides existing internally in infected seed, the bacteria live in infested soils.

Increasing the resistance of tobacco ring-spot virus to aging in vitro by use of carbolic acid. R. G. HENDERSON.

In preliminary experiments it has been found that a small quantity of caroblic acid added to expressed juice increases the resistance of the tobacco ring-spot virus to aging.

Virus-infected juice to which sufficient 5 per cent carbolic acid solution was added to make a concentration of 0.25 per cent was highly infectious after incubating for 7 days at 27° C. The virus in juice treated with toluene was not infectious on the seventh day and in untreated juice on the third day.

Water loss in tomato mosaic. J. W. HEUBERGER and J. B. S. NORTON.

Detached mosaic leaves lost 62 per cent of their weight by drying, while healthy leaves lost 39 per cent. Standard cobalt-chloride paper readings on leaves on the plant showed that mosaic leaves were transpiring at a much faster rate than healthy leaves, especially on the upper surface.

Plants grown in nutrient solution showed greater transpiration per gram of dry weight and per leaf-surface area in long-infected mosaic plants than in healthy ones. There was a sharp drop in transpiration coincident with the appearance of the first visible mosaic symptoms, but no certain effect of the virus before that time was observed, as shown by relative water loss or by difference in dry weight. The transpiration rate of the mosaic plants gradually increased after the initial sharp drop. The plants used were selected for equal transpiration, at which time half were inoculated.

Bound water in leaf tissues of heat-resistant and heat-susceptible inbred strains of yellow-dent corn. J. R. HOLBERT and B. C. FRYE.

Total-, free-, and bound-water determinations made by heat-of-fusion-of-ice method, July 17 to August 3, 1932, indicated that water-binding capacity of leaf tissue of heat-resistant strains of yellow-dent corn increased as heat and drought continued, with temperatures ranging from 95° to 103° F. From July 19 to 26, total-water content decreased 5.4 per cent and bound water increased 62.1 per cent (wet basis), or 35.2 per cent. (dry basis). On second day following one-half inch of rain on night of July 25, which resulted in higher relative humidity and lower air temperatures, there was another marked shift in bound-water and free-water equilibria in direction of condition existing prior to heat and drought period; namely, total-water content increased 1 per cent and bound water decreased 23.2 per cent (wet basis), or 21.5 per cent (dry basis).

Water-binding capacity of comparable leaf tissues of heat-susceptible strains increased very little as heat and drought continued and, in some strains decreased significantly. During first 3 days after heat and drought period had passed, heat-susceptible strains made phenomenal growth, and their water-binding capacity increased rapidly and almost equalled that of heat-resistant strains.

Prehardening for heat as well as for cold has been found associated with marked increases in water-binding capacity. (Cooperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, the Illinois Agricultural Experiment Station, and Funk Brothers Seed Company).

Bacterial leaf blight of dent corn. J. R. HOLBERT, CHARLOTTE ELLIOTT and BENJAMIN KOEHLER.

Bacterial leaf blight of corn was prevalent throughout Illinois and other parts of the Corn Belt during 1932, occurring in all of the 66 fields surveyed. By the middle of August some strains and fields presented a general appearance somewhat similar to severe firing from heat and drought. Loss in green-leaf area, directly traceable to local bacterial infection, ranged from a trace to more than 50 per cent, with an average of 16.6 per cent.

Numerous isolations have shown that in most cases the wilt organism present in these leaf lesions was not present in the same leaf veins farther down in the leaf blade nor in

the sheath or bundles of the stalk below the infected leaf. Differences in strains of the pathogen have been noted.

The reduction in leaf area apparently increased susceptibility to Diplodia stalk rot and to chilling and freezing injuires and decreased breaking resistance of stalks and total yield and quality of grain. Similar results were obtained by artificially removing comparable amounts of green-leaf area in plots relatively free from leaf blight.

Different inbred strains and their crosses showed marked differences in resistance to bacterial wilt.

(Cooperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, Illinois Agricultural Experiment Station, and Funk Brothers Seed Company).

Differences in size and shape of smut balls of two physiologic forms of Tilletia tritici. C. S. HOLTON.

Observations have shown that 2 physiologic forms of *Tilletia tritici* that attack Hohenheimer wheat may be distinguished by differences in size and shape of their respective smut balls. During the 2 years that these 2 forms have been under observation in the field, 1 of them produced large and somewhat elongate smut balls and the other produced comparatively small and distinctly rounded smut balls. These differences were sufficiently striking and constant to permit positive identification of each of these 2 forms by these means. In addition to these differences, these 2 forms differ also in pathogenicity, prominence of spore-wall reticulation, and, to some extent, in the rate of chlamydospore germination.

(Cooperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Washington and Oregon Agricultural Experiment Stations).

Inheritance of chlamydospore characteristics in oat-smut fungi. C. S. HOLTON.

The F_1 chlamydospores of crosses between monosporidial lines of *Ustilago avenae* and *U. levis* are echinulate. Approximately 99 per cent of the F_1 sporidia of all the species hybrids studied were non-culturable, and, therefore, a definite segregation ratio for chlamydospore markings could not be determined. However, both echinulate and smooth chlamydospores were segregated in the F_2 generations, which were produced by inoculating with F_1 chlamydospores. The echinulate chlamydospores predominated in all cases.

A cross between two of the F_1 monosporidial lines referred to above produced a buff smut, the chlamydospores of which were smooth and hyaline. The F_1 chlamydospores of crosses between this buff smut fungus and *U. levis* were smooth and brown, and in crosses between the buff smut fungus and *U. avenae* they were echinulate and brown. In the hybrids produced by crossing the buff smut fungus and *U. levis*, the color of chlamydospores segregated in a 3:1 ratio. Segregation studies in the hybrids produced by crossing the buff smut fungus and *U. avenae* have not been completed.

(Cooperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Washington Agricultural Experiment Station.

Influence of root rot on peas. March of the disease. JAMES G. HORSFALL and Z. I. KERTESZ.

An unfolding picture of the incidence of disease on pea roots caused by *Pythium* spp., *Rhizoctonia solani, Ascochyta pinodella, Mycosphaerella pinodes, Fusarium martii*

pisi, and other microorganisms, and the influence of this disease complex on the morbid physiology of the plants was obtained by collecting 50 random plants weekly during the 1932 season from an area artificially infested with heavily contaminated field soil and from a contiguous area of normal soil. Trend curves show how the incidence of disease was correlated with temperature and rainfall and how it stunted the plants; how it decreased the relative and absolute amounts of dry matter per plant; why this decrease was due to disease alone and not to low fertility or soil toxins in the infested soil; how the disease cut short the blooming period, resulting in fewer pods and peas per plant, although the number of blossoms or pods was a function of the dry weight per plant (1 pod per 0–90 gm. dry matter) irrespective of disease; how root rot forced a larger proportion of the total dry material in each plant into the peas themselves; and how it curtailed by 20 per cent the yield of "fancy" grade peas per unit area.

Sclerotium diseases of grains and grasses. C. W. HUNGERFORD and RUTH REMSBERG.

Diseases of grains and grasses produced by several sclerotial fungi that appear in the field after the snow melts have been increasing in occurrence and importance in the high-altitude regions of Idaho during the last few years. Fourteen cultures have been obtained of these organisms, whose optimum temperatures for growth range from 0° to 10° C. These 14 fungi have been placed in 4 groups, according to their morphological and physiological characteristics. One of these groups corresponds in growth characteristics to a culture of *Typhula graminum*, supplied by H. Tasugi of Japan. Attempts made to obtain the perfect stage of these organisms have not been successful. Pathogenicity of several of the organisms has been established by both laboratory and field inoculations. The disease apparently caused by *T. graminum* is best controlled by late seeding and also by using resistant varieties of cereals.

Zinc hydroxide, a substitute for calcium hydroxide in arsenical sprays. R. H. HURT.

Zinc hydroxide seems to be a promising substitute for calcium hydroxide for the prevention of arsenical injury to the foliage of peach trees and snap beans. This material, in combination with arsenicals, may be used either as a dust or as a liquid spray. In either case the zinc hydroxide should replace the hydrated lime pound for pound. For the prevention of arsenical injury in large commercial spraying operations, it will no doubt be more economical to use the zinc-lime combination (8 lb. zinc sulphate, 8 lb. hydrated lime, and 100 gal. water) that is now in general use in Virginia as a peach spray. But, for small-scale operations, zinc hydroxide in combination with arsenicals, should prove economical and effective when used as either a dust or spray. Present results show that certain varieties of apples are subject to russeting by zinc hydroxide. Such injury, however, does not seem to occur when the zinc hydroxide is used in combination with sulphur. Zinc hydroxide may be prepared in the powdered form and then used or stored in the same way as hydrated lime.

Peach mosaic. LEE M. HUTCHINS.

A new virosis of the peach has been discovered in Texas. Known distribution is confined to a few counties in the central and in the southern portions of the State. The disease is spreading, a few home orchards are severely infected, but occurrence is as yet rare in commercial orchards. The disease is communicable by budding and by root grafting. Outstanding characters are: striking mosaic patterns in young leaves, an abundance of small, crinkly leaves with wavy margins, short internodes, clusters of twigs that somewhat resemble witches'-brooms, and irregular, "bumpy" fruits. The mosaic character of the leaves may be fugitive, and the twigs behave variously in growth characters.

Bacterial wilt of corn. S. S. IVANOFF.

An underground agent of transmission of Stewart's wilt disease of corn was found to be the western corn root worm, the larval stage of *Diabrotica longicornis*. Such larvae, which had fed upon the roots of plants infected with *Aplanobacter stewarti*, repeatedly transmitted the disease when placed on the roots of healthy plants in the greenhouse. In addition to the typical Stewart's wilt organism several bacterial cultures were isolated from wilted plants from various localities and were purified by single-cell isolations. Following their inoculation into corn, there appeared certain symptoms, such as leaf stripes, stalk rot, yellowing, and wilting, which have frequently been associated with Stewart's wilt. Field inoculation trials with these bacteria on yellow-dent and sweet corn showed differences both in the severity of disease in individual plants and in the percentage of disease in the inoculated plants. Bacteriological studies thus far have shown that these cultures differed consistently both from the typical Stewart's wilt organism and from one another in colony characters and in certain physiological reactions.

Effect of sulphuric acid and aluminum sulphate, as used for the control of damping-off of conifers, on soil pH. L. W. R. JACKSON.

pH determinations made in the seed beds at a number of nurseries throughout the United States show that the reaction change is restricted to the upper soil layer. For most of the soils tested, the surface application of either sulphuric acid or aluminum sulphate did not change the pH much below a depth of 2 in. The maximum reaction change, as shown by the lowest pH, usually occurs at a depth of ½ in. The degree of acidification at the time of treatment depends on the nature of the soil.

Effects of H-ion and aluminum-ion concentrations on conifer damping-off. L. W. R. JACKSON.

Seedlings of *Pseudotsuga taxifolia* and *Pinus ponderosa* were grown and inoculated with Pythium and Rhizoctonia in liquid and quartz-sand cultures. The pH varied with intervals of 1 unit from 2.5 to 8.5. A nutrient solution, stable through a wide pH range in the presence of iron and aluminum, was developed by using disodium glycerophosphate as a phosphate source. In liquid cultures without aluminum, damping-off percentages increased from 0 at pH 2.5 to a maximum near the neutral point. In sand cultures damping-off percentages also increased with the pH. In sand cultures the addition of aluminum-ions by means of aluminum sulphate appeared to cause further decrease in damping-off at pH 3.5 but not at pH 6.5. pH 2.5 was always toxic to seedlings, while at pH 3.5 growth was excellent. Fungi were grown in the same solution and at the same pH. Growth of several Pythium cultures from both acid and alkaline soils was inhibited at pH 2.5 and 3.5 while it increased from pH 4.5 to 6.5, and then decreased to almost complete inhibition at pH 8.5. There was also a relationship between pH and chlamydospore and oospore production. Rhizoctonia was able to grow over a wider range of acidity, making appreciable growth at pH 3.5.

Physiologic forms of Bremia lactucae on lettuce. IVAN C. JAGGER and NORMAN CHANDLER.

In breeding lettuce for resistance to mildew (*Bremia lactucae*), several apparently distinct physiologic forms of the fungus have been encountered. In trials at Sanford, Fla., in 1922, 9 varieties of lettuce showed a high degree of resistance. The same varieties showed similar resistance at Chula Vista, Calif., during succeeding seasons. In 1926 only 2 of these varieties showed marked resistance in England to the apparently

distinct physiologic form of the fungus encountered there. In 1927 3 varieties were highly resistant to a third physiologic form prevalent that season in Imperial Valley, Calif.

The variety *Romaine blonde lente à monter*, obtained from France, has, so far, shown considerable resistance to all forms of the fungus encountered. Crosses with this have given several strains of New York or "Iceberg" type lettuce that are highly resistant to mildew at Chula Vista. In central California there seems to be a fourth physiologic form of mildew, which attacks several of these strains in various degrees, but, so far, the strain "Imperial D" has proved practically immune. Recent parallel inoculations with these two physiologic forms of *Bremia lactucae* have demonstrated marked differences in their ability to attack several strains of lettuce under similar conditions.

Nature of injury caused by potato leaf hopper on forage legumes. HOWARD W. JOHNSON.

Artificial inoculation with juice from yellowed and reddened leaves and from adults and nymphs of *Empoasca fabae* failed to produce symptoms of the injury, nor did symptoms develop on plants started as shoot cuttings from yellowed and reddened plants. Confining an adult *E. fabae* upon restricted areas of the leaf petioles of Ladino clover for 8, 16, and 24 hours resulted in the redding and yellowing of about 20, 60, and 50 per cent of the leaves, respectively. With the 24-hour feeding exposure, an additional 40 per cent wilted rapidly and turned brown. As compared with green leaves from non-infested plants, the yellowed and reddened leaves of alfalfa and Ladino clover are higher in dry matter, osmotc presesure of cell sap, reducing sugars, sucrose, starch, total polysaccharides, and alcohol-soluble nitrogen but are lower in total nitrogen. Symptoms almost identical with those caused by the feeding of this leaf hopper were produced artificially by mechanically severing all but one of the vascular bundles in Ladino clover petioles and by girdling Ladino petioles and alfalfa stems with live steam. The chemical changes in leaves reddened and yellowed by artificial girdling and by leaf hoppers were essentially the same. These studies indicate that the reddening and yellowing caused by this leaf hopper are not the result of the injection of a specific inciting agent; virus, or toxin but are caused by an overaccumulation of the carbohydrate products of photosynthesis, especially the osmotically active reducing sugars.

Cucumber mosaic on tobacco in Wisconsin. JAMES JOHNSON.

Effect of leaf-rust infection on water economy and growth of two wheat varieties. C. O. JOHNSON and E. C. MILLER.

Two varieties of spring wheat, one susceptible and the other resistant to leaf rust, were grown in sealed containers in the greenhouse and the water requirement determined for plants of various groups, arranged according to the time of initial leaf-rust infection.

Following is the amount of water, in grams, required by each group of the varieties Pusa No. 4 (susceptible) and Warden (C. I. 4994) (resistant), respectively: 905.3 and 500.8, inoculated first in seedling stage; 869.9 and 490.0, inoculated first in jointing stage; 791.4 and 509.3, inoculated first in boot stage; 619.1 and 480.7, inoculated first when fully headed; 456.8 and 510.8, non-inoculated controls.

In the susceptible variety, the water requirement increased with increasing length of association of host and parasite. This was due principally to the depression of such plant characters as height, leafiness, tillering, and size of stems. Root development, date of heading, and date of maturity also were much retarded in infected plants of the

susceptible variety. These retardations were less marked in the resistant variety. The height of inoculated plants of the resistant variety was slightly reduced and the time required to mature slightly increased, but the yields of tops, grain, and roots were not materially affected.

Two stem cankers of the China aster. L. R. JONES and REGINA S. RIKER.

Two diseases of the China aster were observed in Wisconsin and Illinois, September, 1932, characterized by cankering of the aster stem that may lead to wilt. Each disease showed distinctive symptoms, but there was enough similarity at certain stages to permit confusion with the familiar Fusarium wilt. The commoner and more serious of these cankers was caused by *Phomopsis callistephi*, described as a new species from Illinois in 1925 by Tehon and Daniels. This disease, as seen in September, differed in general from the Fusarium wilt in that (1) it seemed cortical rather than vascular; (2) it developed as a lateral canker on the aboveground stem rather than from the roots as a basal stem rot; (3) it showed abundant pycnidia on the diseased stem surface in the later stages. Phomopsis occurred in 4 out of 5 cloth-house aster plantations visited in Wisconsin and Illinois. In the worst case, where asters had been longest in culture, more than half of the aster plants of some strains were attacked. The other stem canker, caused by *Botrytis* sp.. was observed twice, in both cases associated with excessive moisture. It was of minor importance and relatively easily identified.

Seed transmission of the virus causing variegation of Abutilon. JOHN Y. KEUR.

The virus that produces variegation in *Abutilon thompsonii* and *A. mulleri* is in a limited way transmissible to some of the seedlings obtained by crossing these 2 clons. Out of 536 seedlings obtained from this cross 287 were green and 249 showed "variegated" characteristics, which could be transmitted in but 4 instances to susceptible green *A. reguellii* scions by grafting.

Effect of carbon dioxide on cultivated mushrooms. E. B. LAMBERT.

By running carbon dioxide under bell jars containing growing cultivated mushrooms, it was shown that the accumulation of carbon dioxide in the air caused abnormal growth, stunting, and even death. Further experiments indicated that these effects were caused by carbon dioxide and not by the dilution of oxygen. It also has been demonstrated that the harmful effects were due principally to the carbon dioxide surrounding the sporophores rather than to that in the interstices of the compost in the bed. Approximately 1 per cent carbon dioxide was the lowest noticeably injurious concentration.

Life-history, morphology, and cytology of Polymyxa graminis. G. A. LEDINGHAM.

This obligate parasitic fungus was discovered at Toronto in 1930 in the roots of Marquis wheat seedlings grown in Ontario soil. Two distinct types of thalli, one consisting of thin-walled zoosporangia and the other of resting sori, are found in the life cycle.

The large, irregular septate zoosporangia are surrounded by a definite membrane and liberate numerous biciliate zoospores through exit tubes.

The resting sori are round to elongate and several are often arranged linearly in the host cell. These multinucleate thalli segment to form spore balls.

Two types of nuclear division occur during the development of both the zoosporangia and the resting spores. Protomitosis occurs in the early divisions concerned with the growth of the thallus. Mitosis is found when segmentation commences.

The character of the resting sori and the occurrence of protomitosis in the growth of the thalli indicate relationship with the Plasmodiophorales. Because of its well-developed zoosporangia, unique among members of this order and showing affinities with the Chytridiales, this fungus is worthy of recognition as a new genus to which the name Polymyxa has been given.

Bacterial twig and blossom blight of raspberry. S. G. LEHMAN.

In June, 1932, the writer received some young diseased raspberry shoots bearing flower clusters with open blossoms and half-grown berries. The stems of the flowers and berries had died back for distances of 1 to 4 in., presenting the general aspect of fire blight (*Bacillus amylovorus*) resulting from blossom infection on apple. The diseased tissues were light brown and showed numerous small white droplets of bacterial ooze. Some of the leaves showed marginal dead areas bordered by brown water-soaked tissue that contained bacteria.

A bacterial organism isolated from the diseased flower stems was found to be pathogenic when inoculated into raspberry cane tips. It has been recovered from artificially inoculated twigs and used in successful reinoculations. This bacterium is also pathogenic on wild blackberry. It has thus far given only negative results when inoculated into apple water sprouts. Inoculations onto raspberry with bacteria isolated from apple fire-blight twigs and thought, but not proved, to be *B. amylovorus* have given negative results. Apparently, no one has published proof that raspberry is a suscept to *B. amylovorus*. Further studies will be necessary to a positive statement as to the relation of the raspberry-blight-producing organisms to *B. amylovorus*.

Crown gall on Sahuaro (Carnegiea gigantea). MICHAEL LEVINE.

Crown gall is unknown in nature in the Cactaceae. The production of well-defined crown galls on Sahuaro, the tree cactus, is reported for the first time. The galls were induced by inoculation of plants 5 to 6 years of age with a virulent strain of *Bacterium tumefaciens*. The growths appear slowly at first and then develop more rapidly as the tumor becomes macroscopically recognizable. Tumors, 1 year after inoculation, are still very young. They section readily and present characteristic structures comparable to those on the beet.

The cells of the crown-gall tissue show an abundance of starch but in no case are mucilage or slime cells observed, although the host tissue in close proximity to the tumor tissue appears to have many more mucilage cells than are found in more distant parts of the plant.

A number of species of Opuntia also were inoculated. Well-rooted plants, as well as parts of joints kept in sterile Petri dishes, failed to respond to inoculations with *Bacterium tumefaciens*.

Elm diseases in America. O. N. LIMING.

The Dutch elm disease is now wide-spread in Europe. Eight cases were found in America and eradicated in 1930 and 1931. No cases were discovered in 1932. Scouting has been limited and other infection centers may exist. In the three seasons specimens from 1,407 suspected trees were cultured at the Dutch Elm Disease Laboratory at Wooster, Ohio. Of these, 1,045 showed parasitic fungi, of which 146 were Verticillium and 336 a fungus referred to Cephalosporium. Trees showing Verticillium one year seem to recover the next, but it is not yet known whether this recovery is permanent; trees affected with Cephalosporium show an increase in the diseased condition the second year. A root disease in southern Ohio, Indiana, Illinois, near-by Kentucky, and West Virginia is a complicating factor in the elm-disease work.

Relation of mechanical injury to foot rot of cereals. J. E. MACHACEK and F. J. GREANEY.

Preliminary greenhouse trials have shown that when injured seed of several varieties of wheat and of hulless oats and barley is planted in soil infested with *Fusarium culmorum* var. *letius*, the damage from foot rot and preemergence blight to the resulting seedlings is greater than when uninjured seed of the same varieties is sown. The germination of wheat seed injured by clipping off a portion of the brush end or by scarifying the surface with sandpaper is only slightly reduced, but the amount of disease is markedly increased.

These results were confirmed by carefully planned field experiments in which scarified and uninjured seed of Marquis and Mindum wheat was planted in infested soil. The "analysis of variance" method was used in analyzing the field data. In 1932 a significant increase in disease rating and a significant decrease in yield were obtained through seed injury. When the disease ratings and yields of individual plots in the field experiments were correlated, a highly significant negative correlation coefficient was obtained.

Effect of pressure and amounts of copper applied in spraying potatoes. E. O. MADER.

A 4-year series of potato-spraying experiments to determine the influence on yield of pressures and amounts of copper applied has given consistently the following results. All sprayed plots outyielded the unsprayed. Using nozzles with a small orifice, size 1.18 mm., the amount applied and the yield per acre increased with each increase in pressure up to 600 lbs. Greater increases in yield were obtained by increasing the pressure from 200 to 400 lbs. than by increasing it from 400 to 600, illustrating the law of diminishing returns. With larger nozzle orifices, giving larger amounts of spray per acre, no increase in yield was secured beyond 400 lbs. Here, also, the law of diminishing returns appears to operate. The increase in yield, with large nozzle orifices over small, was greatest at 200 lbs. pressure, less at 400 lbs., while at 600 lbs. pressure there was a slight decrease in yield. These increases in yield are due to the better distribution of the spray at higher pressures and to the application of larger amounts of copper.

Evidence of stimulation of potatoes by Bordeaux mixture. E. O. MADER.

Four years of experimental work affords direct evidence of copper stimulation in sprayed and dusted potatoes. With moderate infestations of leaf pests and absence of blight, the greater the amount of copper applied during the season and the better the distribution (higher pressure) the greater the number of leaflets per plant, the higher the total green weight of tops, and the longer the plants remain green. Despite this increase in top growth, the largest yields and most uniform tubers were obtained with applications totaling 70–80 lbs. of copper sulphate per acre for the season. Stimulating top growth by applying the greater part of the copper during the fore part of the season gave a significant increase in yield of about 30 per acre over plots in which the greater part of the copper was applied during the latter part of the season. Analyses for copper show that the amounts stored in tubers from sprayed or dusted plots increased with the amounts of copper sulphate applied during the season. More copper is found in tubers from plots receiving increasing concentrations than in those receiving decreasing concentrations.

Disease of cultivated sweet violet caused by Sphaceloma. L. M. MASSEY, R. P. WHITE, and A. E. JENKINS.

The disease affecting outdoor and greenhouse violets, in one case identified possibly as edema, were severe in New York in 1929, and in Pennsylvania in 1932. It was

found in Georgia in 1925–1927. Lesions may be numerous, almost covering the plant. Stems, peduncles, and petioles are sometimes noticeably swollen and leaves distorted. Lesions are generally whitish to vinaceous buff; on stems, peduncles, and petioles they are linear to elongate, 5 ± mm. in length, raised or depressed; on leaves generally circular or nearly so, commonly visible at first on lower surfaces as minute water-logged areas, enlarging to at least 3 mm. across, often raised on one leaf surface and depressed on the other.

The Sphaceloma causing the disease is apparently undescribed, at least in this genus. Conidiophores are typically hyaline, soon becoming colored, 0 to 1-septate, 9–12 $\mu \times 2$–4 μ, pointed or obtuse; the conidia are spherical to oblong-elliptical, of various sizes, often 2–3 $\times$ 3–7 μ; hyaline or colored. Three-week-old cultures on slants of potato-dextrose agar were raised, wrinkled, about 1 cm. across, and so brown as to appear nearly black, bordered by dark olive buff; corresponding cultures on cornmeal were nearly smooth, appressed, and ochre red. A more complete description, with a name, will be published later.

Form of toxicity surface for copper sulphate and for sulphur in relation to conidia of Sclerotinia americana. S. E. A. McCALLAN and FRANK WILCOXON.

The effect of a toxic agent on the germination of fungus spores is best shown quantitatively by means of the *toxicity surface*, a solid model showing the relation between germination percentage, concentration of toxic agent, and time. Two such models are exhibited for copper sulphate and for sulphur dust. It is pointed out that such models enable the investigator to compare the relative accuracy of the different methods of performing toxicity experiments, since the accuracy of a determination at any point is related to the germination percentage obtained and to the slope of the toxicity surface at that point. The form of these surfaces might also lead to certain deductions regarding the mechanism of toxic action.

Spores in the upper air. F. C. MEIER, J. A. STEVENSON, and VERA K. CHARLES.

In the course of efforts to obtain additional information concerning fungus spore content of upper air currents, movement of such spores and their precipitation and viability after exposure at high altitudes, agar-plate collections made in 1932 on 5 flights over the eastern United States netted cultures of some 50 organisms. Flights by the senior writer on routine trips of the U. S. S. Los Angeles and by airplanes were made possible by cooperation with the Navy, Army, and Coast Guard. Collections made at altitudes of 500 to 18,000 ft. indicate the strong possibility of certain types of spores of fungi that cause plant diseases travelling long distances in viable condition before falling to start new local infections.

Spore content at different altitudes varied with atmospheric conditions during and preceding the flight with usually a decided thinning out above 8,000 ft. Viable spores of Pestalozzia were collected March 22, 18,000 ft. above Washington in a strong west wind. Fungi of the following genera have been identified, Acremoniella, Alternaria (Macrosporium), Aspergillus, Chaetomium, Cladosporium, Coniothyrium, Dematium, Epicoccum, Fumago, Fusarium, Helminthosporium, Penicillium, Pestalozzia, Sclerotinia, Stachybotrys, Stemphyllium, and Trichoderma.

A Pythium disease of turf. JOHN MONTEITH, JR.

Pythium was isolated in 1926 from diseased creeping-bent turf at the Arlington turf garden, Rosslyn, Va. The species was identified by Drechsler as *Pythium butleri*. Inoculation in the greenhouse proved the fungus to be a vigorous parasite on various grasses, included species of Agrostis and Poa. Affected patches, usually ½ in. to 4 in. in

diameter, first appear blackened and water-soaked but soon shrivel and turn brown. These patches commonly occur in groups, frequently in streaks, apparently due to distribution of spores by water washing over the surface or on mowers or the shoes of persons walking on the turf. Patches often coalesce and destroy large areas of turf. The disease has been identified on golf courses and lawns in the vicinity of Washington, D. C., Philadelphia, St. Louis, and Chicago. It has been reported in many other sections. The disease is most destructive in periods of high temperature accompanied by abundant moisture. It caused extreme damage to turf during 1931. Inoculations showed the fungus capable of attacking plants over a wide temperature range, with an optimum of 35° C. Since abundant moisture is required for development of this disease it may be checked by judicious watering of turf. No satisfactory fungicidal treatment has been developed, although spraying with solutions of corrosive sublimate has shown some promise.

An undescribed sclerotium fungus prevalent in northeast Texas. D. C. NEAL and R. E. WESTER.

A fungus resembling *Phymatotrichum omnivorum* was discovered at Greenville, Texas, in September, 1932, growing on decayed cotton stalks and roots a few inches below the surface of the soil, following a period of wet weather. Sclerotia formed in abundance as elongate swellings along the mycelial strands similar to the cotton-root-rot fungus. They were white to pale yellow,, depending on age, and varied considerably in size and shape. They averaged about 1×5 mm., were round to ovoid, ellipsoid, variously constricted, and often forked at the strand connections. The sclerotia were smooth and formed of anastomosed hyaline hyphae.

Features that distinguish the fungus from *Phymatotrichum omnivorum* are the finer texture of the strands and sclerotium formation on agar. The mycelium is septate and branching is either opposite or alternate just below the septa. A characteristic behavior of certain new cells arising from the side of a parent hypha is to grow in opposite directions. In some cases the lower portion of the cell grows downward for only a short distance, while the upper part continues growth and forms new cells either parallel, or at an angle of 45°, to the original hyphae. Pending further studies, the name **Ozonium texanum,** sp. nov., is proposed.

Morphology and life history of the cotton-root-rot fungus in Texas. D. C. NEAL, R. E. WESTER, and K. C. GUNN.

Comparisons of the structure of the strand hyphae and sclerotia of *Phymatotrichum omnivorum* have shown that some strands are, in reality, elongated sclerotia comparable to the rhizomorphs of certain basidiomycetes and function not only to spread the fungus vegetatively but also to maintain it in a viable condition during periods of inactivity—a point that was recognized by one investigator as early as 1916. Strands obtained from old cotton roots in fallow plots from areas planted in nonsusceptible crops and from soil cultures several months old were viable in germination tests. The importance of the strand hyphae in the overwintering of the disease in the soil was further demonstrated by pure-culture isolations from some of these strands and by infection experiments.

Sclerotia occurred more abundantly in primary centers of infection following prolonged grain rotation or fallow periods than in plots planted continuously to cotton. The gross morphology and cellular structure of some of these sclerotia indicate that they had formed in the soil at the time of the last cotton planting and had remained in a viable condition during the intervening period of grain rotation or fallow treatment.

Breeding Fusarium-yellows-resistant celery. RAY NELSON and L. C. COCHRAN.

For the past 5 years yellows (*Fusarium* sp.) has become increasingly serious in the commercial varieties of easy-blanching celery, and, in 1931, under especially favorable conditions, the disease caused a loss of $250,000 to Michigan growers. The tall strain of Golden Self Blanching, the leading market variety, is extremely susceptible to yellows. The so-called short-strain varieties, like Golden Plume, are moderately resistant, but under favorable conditions for the disease they produce unsatisfactory crops.

A number of selections were made from fields of the tall strain in 1930, but only one plant was carried through the winter to seed production. The F_1 and F_2 progenies of this plant have shown high resistance when tested in greenhouse and field under the most favorable conditions for yellows. The plants of this variety ("Michigan Golden") are intermediate in type between the tall and short strains, and field tests have indicated that they possess satisfactory commercial qualities. Seed in sufficient quantity for field testing in 1933 is now available.

Other selections, made in 1931, from both the tall and short strains are being tested and reselected. Some of these selections have shown considerable resistance to yellows, but further improvement is necessary before they can be considered satisfactory for commercial use.

Influence of pollen and ovule infection in seed transmission of bean mosaic. RAY NELSON and E. E. DOWN.

It is known that bean mosaic is transmitted irregularly through the seed and that not more than one-half of the seeds are infected in pods harvested from plants arising from diseased seed. To test the possibility of pollen infection and to determine the relative effects of pollen and ovule infection in seed transmission of the disease, crosses were made between Refugee and Early Prolific, varieties very susceptible to mosaic.

The incidence of mosaic in hybrids between mosaic Refugee and healthy Early Prolific was approximately the same as in hybrids between healthy Refugee and mosaic Early Prolific. The mosaic parent in all crosses was produced from infected seed. The results indicate that about $\frac{1}{4}$ of the ovules and pollen grains are infected with virus.

In crosses between Refugee and Robust, a highly resistant variety, about $\frac{1}{4}$ of the hybrid seedlings were severely affected with mosaic.

Studies on the resistance of wheat and oats to stem rust. MARGARET NEWTON and A. M. BROWN.

A preliminary study of the nature of resistance in wheat and oat plants to stem rust, *Puccinia graminis*, has shown that, at least in some varieties, meristematic and newly differentiated tissue produces an entirely different infection type from older tissues. In the adult stage, Hope and H–44–24 are highly resistant and Pentad and Acme moderately resistant to all physiologic forms of wheat stem rust, *P. graminis tritici;* yet, when, by injection through the sheath, the spores are brought into contact with newly formed tissue, pustules of a susceptible type are produced. Oat plants, when inoculated in the same manner with forms 21 and 36 of wheat stem rust, develop infection areas with pustules of types 2, 3, and even 4.

Stripe rust in Canada. MARGARET NEWTON, T. JOHNSON, and A. M. BROWN.

Puccinia glumarum tritici has been collected in Canada as far east as 102° W. longitude, or a little beyond the eastern limit reported for this rust in the United States. Two physiologic forms have been found in Canada; at Duncan, British Columbia, a virulent one, which attacks most of the common and durum varieties, and at Olds, Alberta,

a much less virulent one. Both of these forms have been isolated from material sent in from the United States. The less virulent form does not appear to be present in Europe, but the more virulent form is similar to one of the well-known forms in Germany (Giessen).

Freshly formed urediniospores retained their viability and were capable of producing good infection after storage for well over 3 months at 5° C. and a relative humidity of 50 per cent. Some spores germinated at the end of 128 days, the best germination occurring at 10° to 12° C.

The reactions of wheat varieties to strip rust were profoundly influenced by temperature. At 78° C. all the hosts tested with the different physiologic forms were completely resistant, while at 54° C. many were completely susceptible. A number of wheat varieties susceptible in the seedling stage have been found to develop considerable resistance in later stages of growth.

Puccinia glumarum hordei has not been isolated so far in Canada. All isolations from barley varieties have proved to be one or other of the above-mentioned *tritici* forms.

Factors influencing type and sequence of tomato-mosaic leaf abnormalities. J. B. S. NORTON and J. W. HEUBERGER.

Types of leaf abnormalities noted in tomato mosaic were filiform-leaf, cut-leaf, fern-leaf, and mottling. Ordinarily tobacco-mosaic virus, as well as the tobacco-mosaic-virus complex (2 or more tobacco viruses) present in Maryland fields, induced the more extreme leaf abnormalities in young tomato plants during periods of low-light intensity and short-day length. Parallel series with cucumber-mosaic virus produced only mottling under the same conditions. Filiform-leaf usually appeared first, followed by cut-leaf and fern-leaf, then mottling only. Under longer-day conditions mottling may be the only effect after the primary bunching of the young leaves is seen. The production of leaf abnormalities appears to be correlated to a greater degree with low-light intensity than with short-day length.

Germinating seeds and seedlings could not be infected prior to the appearance of green color.

Reaction of tissues from individual plants to soft-rot bacteria. C. R. ORTON.

A pathogenic strain of the *Bacillus carotovorus* type failed to rot certain sterile carrot blocks cut from stored roots. Differences in susceptibility of individual plants were suspected and it was found in duplicated tests on individual cabbage heads that 2 out of 10 or 20 per cent of stored cabbages were very highly resistant to rot when inoculated with *B. phytophthorus* or *B. aroideae*, both strains reacting in approximately the same manner. Under comparable conditions of high humidity the midveins of cabbage were about 15 per cent more susceptible than the laminae of cabbage leaves taken near the midvein.

Tests of 4 varieties of carrots taken from the soil at maturity and split lengthwise show 100 per cent susceptibility to both strains of soft-rot bacteria but, after storage for 3 months, showed only 73 per cent susceptibility to *Bacillus aroideae* and 53 per cent susceptibility to *B. phytophthorus*. Similar results were obtained with inoculations on stored turnips in which approximately 70 per cent of the individual roots rotted when inoculated with either strain.

It is apparent that carrot roots that are susceptible to bacterial soft-rot at growth maturity may undergo changes in storage that induce resistance in certain roots and that laboratory and classroom tests of cultures should be conducted on at least 10 individual roots or plants to assure one that the organism is pathogenic.

Serum-agglutination studies with soft-rot bacteria. C. R. ORTON and ALFRED R. STANLEY.

Recent work in this country and in England has led some investigators to the conclusion that *Bacillus aroideae, B. carotovorus, B. phytophthorus,* and other bacteria causing soft rots in vegetables can be distinguished serologically and, on this basis, are to be regarded as separate species.

Studies with 50 isolants of bacteria of this group show that these organisms are not to be specifically distinguished by agglutination tests. For instance, 2 cultures of *Bacterium dissolvens* isolated from stalk rot from 2 varieties of sweet corn are identical in routine physiological tests but show no sign of cross agglutination. However, when using an antiserum from one of these cultures, cross agglutination is obtained with *Bacillus coli communis* and a *B. aroideae* from Japan isolated from Pai Ts'ai.

Likewise 2 cultures of *Bacterium tabacum* from Pennsylvania were agglutinated by *Bacillus aroideae* antiserum to as great an extent in the case of 1 culture and to a greater extent with the other culture than was a culture of *B. aroideae* from Japan.

It is evident that these numerous soft-rot bacteria, as well as such leaf-spotting forms as *Bacterium tabacum,* are not to be considered as distinct species but rather as variants of the *Bacillus coli* group.

A bacterial blight of the broad bean in Louisiana. L. H. PERSON.

In the spring of 1932, fields of the broad bean in Louisiana were severely attacked by a blight. The leaves were covered with circular, dark brown to black spots, varying in diameter from 2 to 5 mm. Usually, the spots would coalesce and the whole leaf would become black and curled and finally die. A bacterium isolated from these spots produced, when inoculated into the stems of healthy plants, a typical streak disease. Streaks extended for ½ to 1 in. beyond the inoculation punctures. In a number of cases the stems were entirely dead in the vicinity of the puncture after 3 to 5 days. Inoculations made by painting the leaves with a water suspension of the bacteria produced typical dark, circular areas, similar to those observed in the field. The disease has been observed in Louisiana for many years, but this is apparently the first report of its occurrence in the United States. Whether it is the same bacterial disease that occurs in Europe has not yet been determined.

Dissemination of fire-blight bacteria by honeybees. A. L. PIERSTORFF and HOWARD LAMB.

In an effort to gain additional information on the dissemination of the fire-blight organism, *Bacillus amylovorus,* by the honeybee, 2 Yellow Transparent trees were enclosed with cheesecloth. A hive of bees that previously had been infested with fire-blight bacteria was placed beneath one tree, just as the blossoms were opening. The fire-blight organisms did not infect the blossoms within this cage as a result of bee visitations.

On the lower branches of another tree, similarly caged, 19 blossom clusters were inoculated by atomizing with infested bouillon when the center blossom opened. Approximately two thirds of the blossom clusters on this tree were blighted by the bacteria being disseminated from the inoculated blossoms by a noninfested hive of bees. Rainfall did not occur during this interim, so that insect dissemination is the only logical conclusion.

After remaining beneath these caged trees for 5 days, both hives were transported to another location and 1 placed beneath each of 2 similarly caged Grimes Golden trees. The blossoms did not become blighted as a result of bee visitations.

The first part of the experiment was repeated in a location farther north that had a later blooming date. Comparable results were obtained.

Combating spinach damping-off by seed treatment. P. P. PIRONE.

Great losses to spinach from damping-off, caused chiefly by a Pythium, occur on Long Island. Following Horsfall's method of combating tomato damping-off by dipping the seed in copper sulphate solution, marked success was obtained with spinach. Treatment consists in soaking the seed for 1 hour in a solution made by dissolving 1 to 2 oz. of $CuSO_4$ in 1 gal. of water. Considerable leeway was found permissible in the matter of concentration and of time of immersion. Increases in stand of from 20 to 75 per cent were common on the sandy-loam soils of Long Island. The average increase in yield on 8 farms was 201 crates per acre, or 65 per cent.

An inexpensive dry treatment was found just as effective as the soak. It consists in shaking the seeds for 5 minutes with cuprous oxide (Cu_2O) at the rate of from 3 to 6 oz. of the dust to 10 lb. of seed.

During the past 2 seasons over 10,000 lb. of spinach seed have been treated in Nassau County. Seedsmen, canners, and growers are now successfully treating spinach seed in advance of the planting season.

Prevalence and relations of 4 soil-borne parasites on the peach trees in the Sand Hills of the Carolinas. R. F. POOLE.

Armillaria mellea, Bacterium tumefaciens, and *Heterodera radicicola,* recognized parasites of the bole and root system of peach, along with *Polyporus curtisii,* the cause of "punky" or heart rot, are widely distributed in the Sand Hill soils. All 4 organisms are rarely observed in the same orchard, but 1 or more of the organisms occur in 90 per cent of the orchards.

Every season these organisms kill from 3 to 5 per cent of the trees, seriously affecting the economic production of the peach crop in the sand hills.

These organisms are, in most instances, indirectly responsible for the death of trees, amounting to 10 to 100 per cent in many orchards following exposures to such low temperatures as 10 and 15° F. in March and early April. Studies of the root systems of dead trees revealed diseased conditions that had prevailed some time previous to the low-temperature injury.

A complex virosis of tobacco. H. M. QUANJER.

It is well known that a "streak" of tomato can be caused by the combined action of a "true" tobacco-mosaic virus and a "healthy" potato virus. A streak, however, can also be produced in tobacco in the same way. The Amersfoorter variety of tobacco, the same as used by Adolf Mayer (1885) and Beyerinck (1896), was inoculated with the classic tobacco-mosaic virus of these authors and at the same time with the "acronecrose virus" (Phytopath. **21**: 577–613. 1931) of apparently healthy Magdeburger Blaue potato. Symptoms of tobacco mosaic appeared in the tops of the plants, and in the bigger leaves the faint, nebulous, later disappearing ring spots, characteristic of the acronecrose virus, appeared. In addition, there occurred a heavy streak on the midveins of the bigger leaves and on the lower half of the stems.

The thermal death point of the classic tobacco virus is 88° C., and the time it may survive in plant extracts at 18° C. is several months; the thermal death point of the acronecrose virus is 66° C., and its longevity in plant extracts at the same temperature is 10 days.

Fungicidal efficiency of a solution of mercuric chloride and potassium iodide. W. P. RALEIGH.

Laboratory tests and preliminary field experiments indicate that the addition of potassium iodide to a solution of mercuric chloride greatly increases the fungicidal effi-

ciency of the solution when used to control Rhizoctonia on potatoes. A 1: 1,200 solution of mercuric chloride, to which 0.25 per cent potassium iodide was added, when used as a dip treatment, proved to be almost as efficient in control of Rhizoctonia as a 1: 1,000 solution of mercuric chloride used as a 1½-hour soak. It was more efficient than a 1: 500 solution of mercuric chloride used as a 3-minute soak or a 1: 500 solution of mercuric chloride, with 1 per cent commercial hydrochloric acid, used as a dip. A 2 per cent solution of potassium iodide, as a dip, did not give satisfactory control of Rhizoctonia in laboratory tests.

The rate of loss of strength of this solution with continuous use has not been determined. Injurious effects have not been noted in preliminary field tests.

A homemade colloidal copper spray. W. P. RALEIGH.

An attempt has been made to perfect a method of home manufacture of a colloidal copper spray. In preliminary tests several procedures were followed and many colloidal materials were used in an effort to get a concentrated mixture in which the copper was in a finely divided state. One of the most promising concentrates was made in the following manner: One pound of copper sulphate was dissolved in 2 qt. of water and 1 pt. of black-strap molasses was added. This mixture was stirred well and made slightly alkaline by adding about 4/10 of a pound of lye dissolved in 1 qt. of water. This concentrate was allowed to stand until it turned yellow, which usually required about a day at room temperature. In preliminary field tests this mixture, used at the rate of the equivalent of 4 lb. of copper sulphate to 50 gal. of water, gave satisfactory control of late blight of potatoes. It is especially adapted to conditions where excessive coverage of the foliage is not desired. Mosaic may be readily read in potato fields sprayed with this material, whereas it is often difficult to read it in fields sprayed with Bordeaux mixture. The spraying procedure is very simple after a quantity of the concentrate is made up.

Seasonal development of hairy root, crown gall, and wound overgrowth on apple trees in the nursery. A. J. RIKER and E. M. HILDEBRAND.

The seasonal development of hairy root, crown gall, and wound overgrowth on nursery apple trees has been studied for 3 years, in a region where hairy root was of considerable economic importance. Although weather conditions during the 3 growing seasons were quite different, the development of disease was similar. Records were kept of such factors as environmental conditions, host development, incubation periods following special treatments, successive stages in the development of artificially induced enlargements, natural occurrence of overgrowths, and insect relations. Incubation periods for the various enlargements were shorter in the summer than in the spring and fall. A relatively small portion of the natural occurrence of hairy root was traced to infection at the time of grafting. However, a large part of the natural occurrence of hairy root seemed to follow natural infection during the latter part of the first growing season and during later growing seasons. Much of the natural infection appeared correlated with such factors as warm weather, active growth of the nursery trees, short incubation periods, decreased protection of the unions by wrappers, and insect activity.

Fusarium strains in relation to wilt of China aster. REGINA S. RIKER and L. R. JONES.

Various strains of Fusaria from wilting asters, *Callistephus chinensis,* received either from Wollenweber (Europe) or Hemmi or Fukushi (Japan), have been tested for pathogenicity in comparison with Beach and Jackson strains of *F. conglutinans* v. *callistephi* with the following results.

Pathogenic: from Europe, *F. conglutinans* v. *callistephi*, *F. conglutinans* v. *majus* (2 strains), *F. oxysporum* f. *6* (4 strains), *F. lateritium* v. *fructigenum;* from Japan, unidentified (3 strains).

Nonpathogenic: from Europe, *F. oxysporum* v. *aurantiacum*, *F. redolens* (2 strains), *F. vasinfectum* v. *lutulatum*, *F. herbarum* f. *1* and f. *2*, *F. herbarum* v. *avenaceum*, *F. scirpi* v. *acuminatum*, *F. equiseti* (2 strains), *F. culmorum*, *F. solani* v. *martii;* from Japan, unidentified (2 strains).

Certain Fusaria, pathogenic on other hosts, proved nonpathogenic on aster, namely: *F. conglutinans*, *F. conglutinans* v. *betae*, *F. niveum*, *F. orthoceras* v. *pisi*, *F. tracheiphilum*, *F.* sp. from celery, *F. sporotrichioides*, *F. anguioides*, *F. arthrosporioides*.

The Wisconsin "wilt-resistant" asters proved resistant to the pathogenic Fusaria listed above, both in greenhouse and field trials, as far as tested, namely: *F. conglutinans* v. *callistephi* (3 strains), *F. conglutinans* v. *majus* (1 strain), *F. oxysporum* f. *6* (3 strains), *F. lateritium* v. *fructigenum* and 2 Japanese strains.

Control of hairy root, crown gall, and other malformations at the unions of piece-root grafted apple trees. A. J. RIKER, G. W. KEITT, E. M. HILDEBRAND, and W. M. BANFIELD.

The control of graft knots at the unions of nursery apple trees, grown from piece-root grafts, has been studied during the past 7 years in the Middle West. The results from the various control methods tried have shown considerable variations in different localities during the same year and in the same locality during different years. Different kinds of enlargements were found in various sorts and degrees of mixtures. Well-matched tongue grafts produced on the average as many trees with smooth unions as did wedge grafts. Of the antiseptics employed mercuric chloride, applied before grafting in a 1–1,000 solution to roots that carried pathogenic bacteria, appeared to have the greatest promise. Adhesive-tape wrappers for piece-root apple grafts appeared to be better than any other single control measure employed. Comparisons of the percentages of smooth trees from grafts wrapped with other commercial wrappers and those from tape wrappers, respectively, show the following average results: on trees 1 year old, 57 to 92; on trees 2 years old, 75 to 91; on trees 3 years old, 73 to 85; and on trees 4 years old, 21 to 53.

The genetics of Sphacelotheca sorghi and S. cruenta. H. A. RODENHISER.

Studies have been made of the segregates from hybrid chlamydospores formed as a result of a cross between a monosporidial line of form 1, *Sphacelotheca sorghi*, and one of a collection of *S. cruenta*. One hundred and two gametic F_1 lines segregated, as regards color of colony, into 4 general groups. Color apparently was governed by multiple factors that segregated independently of those governing sex, species, and rate and type of growth. In interspecific crosses, the factor or factors determining the *cruenta* type of sorus are dominant. Ninety-nine F_1 monosporidial lines isolated from 39 hybrid chlamydospores were paired in back crosses with one of two monosporidial lines of opposite sex of the recessive parent, *S. sorghi*, and used to inoculate Reed kafir sorghum. Segregation was observed among the back-crossed progenies for factors governing species characters as well as the color of the peridia surrounding the sori, the degree to which the plants were stunted, and the amount of vegetative tissue destroyed in the panicle.

Pathogenicity of certain hybrids of covered and loose smuts of sorghum. H. A. RODENHISER and B. F. BARNES.

Intraspecific crosses were made by pairing monosporidial lines of physiologic forms 1 and 2 and of 1 and 3 of *Sphacelotheca sorghi*. Likewise, interspecific hybrids were

made by pairing a monosporidial line of form 2 and one of form 3, respectively, with a monosporidial line of *S. cruenta*. On Reed kafir (C. I. 628), which is susceptible to all known forms of *S. sorghi* and to *S. cruenta*, the intraspecific crosses were more virulent than were inbred lines of either parental form. Interspecific hybrids were less virulent on this variety than were the inbred parental lines. In general, on the varieties of sorghum susceptible to one inbred parent and resistant to the other, both intra- and interspecific F_1 chlamydospores proved to be intermediate in their virulence. On kafir × feterita (H. C. 2423), the interspecific hybrid, form 3 of *S. sorghi* crossed with *S. cruenta*, was only slightly less virulent than either parent. Spur feterita (C. I. 623) was immune in all pathogenicity tests.

(Cooperative investigations between the Division of Cereal Crops and Diseases and Division of Dry Land Agriculture, Bureau of Plant Industry, U. S. Department of Agriculture).

Comparative studies of field collections of Ustilago hordei and U. nuda. MABEL L. RUTTLE-NEBEL.

A summary of head and spore types obtained from the examination of 150 heads of *Ustilago hordei* and *U. nuda* collected near Geneva, N. Y.

No.	Head	Spore mass		Individual spores		Remarks
	Type	Compactness	Color	Wall	Germination	
1	Covered	Compact	Very dark chocolate brown	Smooth	Promycelia and sporidia	Typical *U. hordei*
2	Covered	Less compact	"	Echinulate	Promycelia and sporidia	Sp. ?
3	Loose	Powdery to compact	Dark chocolate brown	Smooth	Promycelia and sporidia	Sp. ?
4	Loose	Powdery to compact	Less dark chocolate brown	Faintly to distinctly echinulate	Promycelia and sporidia	*U. nigra* Tapke? Blossom inoculation gave no infection
5	Loose	Powdery	"	Echinulate	Much-branched germ tubes	Sp.? Seed had been dusted with Ceresan
6	Loose	Powdery	Olivaceous brown	Echinulate	Much-branched germ tubes	*U. nuda* ?
7	Loose	Powdery	"	Echinulate	Germ tubes not so branched as in 5 and 6	Typical *U. nuda.* Blossom inoculation produced 100 per cent infected seed

Notes on Bordeaux mixture. GEORGE E. SANDERS.

The addition of an excess of lime to Bordeaux mixture increases its value in the control of early blight of potatoes. In a modification of the Kedzie formula, it was

found that mixing the arsenite of soda solution with the copper sulphate solution and combining the majority of the arsenic with the copper before the addition of lime result in a much safer arsenical than can be obtained by adding arsenite of soda to the completed Bordeaux mixture.

Because of the lack of agitation in traction sprayers when the hydrated lime is added to the copper sulphate solution, a type of Bordeaux mixture results that is inferior to that resulting from the old method of pouring diluted solutions together. Fertilizing elements made up of synthetic urea and monopotassium phosphate added to standard Bordeaux mixture show that 1 lb. of urea and 3 lb. of monopotassium phosphate may be used with safety in 50 gal. of Bordeaux mixture. The results indicate that considerable economy in the use of fertilizers may result from this procedure.

A new necrotic virus disease of potatoes. E. S. SCHULTZ and W. P. RALEIGH.

A few necrotic potato plants of the variety British Queen were found in a field near Eureka, California, in 1929. This necrosis, called British Queen streak, is manifested by fine necrotic streaking of leaf veins and petioles and by slight streaking on stems. It differs from top necrosis or seedling streak, inasmuch as it involves at first the older leaves and causes smaller necrotic lesions than either top-necrosis or stipple streak. Moreover, no tuber necrosis has been observed.

Leaf-rubbing inoculations to Turkish tobacco within 10 days produced local, not invariably systemic, and at first light green circular areas followed by white and finally by brown spots. Similar inoculations to Globe tomato and *Datura stramonium* resulted in local and systemic infection, manifested at first by light green and finally by necrotic, circular spots. Necrosis appeared sooner at 60° to 65° F. than at 70° to 75° F. Although the symptoms of British Queen streak on tobacco and tomato resemble those figured for spotted wilt of tomato in Australia, observations indicate that these diseases may not be identical.

Resistance of potato to latent mosaic. E. S. SCHULTZ and W. P. RALEIGH.

Leaf-rubbing and tuber-graft inoculations with latent mosaic, which is generally present in masked condition in Green Mountains and other important potato varieties, have failed to infect certain potato seedlings, while similar inoculations on other seedlings have infected every plant. Under field conditions these potato seedlings have reacted like the artificially inoculated plants, viz., certain seedlings have not contracted latent mosaic, while others similarly exposed became infected. Observations on the reaction of different potato varieties and seedlings to latent mosaic indicate that some manifest this disease as severe necrosis, while others are very resistant to it.

Investigations involving isolation of different types of mosaic have shown that resistant potato seedlings can be used in isolating streak and mild, leaf-rolling and other mosaic types from latent mosaic.

Resistance of rosaceous plants to fire blight. LUTHER SHAW.

The relative fire-blight resistance of various rosaceous plants was determined by a standardized procedure, which involved artificial inoculations of the shoots with *Bacillus amylovorus* and measurements of the fire-blight lesions. Differences in resistance, ranging from slight necrosis around the points of inoculation to death of entire shoots, were found among potted plants of 31 rosaceous species, involving the following genera: Amelanchier, Aronia, Cotoneaster, Crataegus, Malus, Pyrus, and Sorbus. Among certain apple varieties studied under both greenhouse and orchard conditions, Northwestern

Greening consistently exhibited high and Yellow Transparent low resistance. McIntosh and Wealthy were intermediate.

The following environmental conditions were found to increase fire-blight resistance in potted apple plants: (1) low soil nutrients, (2) relatively low and relatively high soil temperatures, (3) relatively high atmospheric temperatures, and (4) relatively low soil moistures. These conditions also resulted in lessened shoot growth. Subjecting plants to 95–98 per cent relative humidity, at 24° C., for varying periods following inoculation greatly lowered their resistance to fire blight.

Positive correlations were found between fire-blight resistance in apple shoots and (1) a low moisture content in the shoots and (2) rapid corking off of the fire-blight lesions.

Relation of growth cycle and nutrition to perennial apple-canker infection. ELMER V. SHEAR and J. S. COOLEY.

Experimental work on perennial apple canker (*Gloeosporium perennans*) has been carried on in the experiment-station orchard at Hood River, Oregon. Hand inoculations with several strains of the organism have been made at 2- or 3-week intervals throughout the year. Infection took place in normal living twigs for a relatively short time only, namely, in the fall and early winter. Susceptibility increased very rapidly from nothing the last of September to approximately 50 per cent early in October and reached its maximum of near 100 per cent in November, where it remained until about mid-December. Mid-December infections were irregular, and, by mid-January, infection could not usually be effected on limbs of 25 or more millimeters in diameter on mature trees. However, on small limbs and on young trees immunity was later and more irregular in its development than on larger limbs. Internodes were less susceptible than nodes.

The influence of nutrition on resistance to canker was determined by inoculating trees having received different fertilizer treatments. Results indicate that trees that had received an excess of nitrate and, likewise, the devitalized trees, such as the checks and those receiving no nitrate, were more susceptible than those in good vegetative condition.

Relationship of Fusarium niveum to the formation of tyloses in melon plants. BAILEY SLEETH.

One- to 4-months-old melon plants (*Citrullus vulgaris*) infected with *Fusarium niveum* show an abundance of tyloses. The abundance of tyloses seems to be correlated with the presence, the quantity, and the proximity of the fungus. Of the infected vascular bundles of the same plant ¼ to all of the vessels may be completely filled with tyloses, while few or none occur in the uninfected bundles. Evidence indicates that the formation of tyloses either precedes or coincides with the spread of the fungus through the xylem. Few or no tyloses were found in fungus-free and apparently normal plants. The striking difference in the number of tyloses in infected and noninfected plants strongly suggests a pathological relationship between the fungus and the formation of tyloses with the subsequent plugging of the vessels. When this mechanical plugging of the vessels becomes sufficient to interfere with the normal flow of water and nutrients in the plant, stunting and wilting occur.

Association of Cercosporella foot rot with a specific ecological area. RODERICK SPRAGUE.

In the United States, the Cercosporella foot rot of wheat, *C. herpotrichoides*, occurs in certain prairie sections of Oregon, Washington, and Idaho. With some exceptions, it is confined to fine or very fine sandy-loam soils, which, in pre-farming days, were covered by a grass sod in which *Festuca* spp. predominated. It is possible

to predict the approximate range of this disease by a study of the vegetation in these prairie areas. Prominent plants in the disease-harboring sections include *F. idahoensis, Agropyron* spp., *Poa sandbergii, Koeleria cristata, Balsamorhiza deltoidea, Olsynium grandiflorum, Tellima* spp., *Fritillaria pudica, Gaillardia aristata* and various species of Lupinus and Cogswellia (Lomatium). (Cooperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Oregon and Washington agricultural experiment stations).

Distribution of physiologic forms of Puccinia graminis tritici in relation to stem-rust epidemiology in 1932. E. C. STAKMAN, LEE HINES, HARRY G. UKKELBERG, and WALLACE BUTLER.

Durum wheats were more severely rusted than bread wheats in the upper Mississippi Valley in 1932, although the opposite usually is true. This is accounted for by the distribution of physiologic forms of *Puccinia graminis tritici.* Fifteen forms were isolated from 465 collections made in northern Mexico and United States. Five forms constituted 92 per cent of all collections, as follows: form 38, 46 per cent; 49, 27 per cent; 36, 9 per cent; 19, 5 per cent; 11, 5 per cent. Forms 38 and 19 infect most hard-red-spring wheats only slightly but often infect durums heavily; the reverse is true of forms 49 and 36, while form 11 infects both groups heavily. Following are the percentages of collections in representative areas from which were isolated forms that infect durums: Mexico, 54 per cent; Texas, 67; Minnesota, 61; North Dakota, 56. Of the Mexican and Texas collections, 54 and 63 per cent, respectively, are harmless to most hard-red-spring wheats in the field. Field observations and results of spore trapping support evidence from the physiologic-form survey that rust was blown northward from Mexico and Texas, although certain forms, notably form 36, apparently originated principally on northern barberries. (Cooperative investigations between the Divisions of Barberry Eradication and Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Minnesota Agricultural Experiment Station).

Some experiments with a yellow mosaic of tomato. W. G. STOVER and M. T. VERMILLION.

The chlorotic areas in leaves of diseased plants are irregular in shape and much lighter in color than in ordinary mosaic. Thus far, successful inoculations have been made in tomato, tobacco, pepper, and *Solanum nigrum.* Susceptibility of *S. dulcamara* is in doubt. Inoculations in China aster, burdock, catnip, cucumber, and curly dock gave negative results. The disease is much more injurious to pepper than ordinary mosaic. The leaves and blossom buds drop off and many of the plants are killed. The virus of yellow mosaic was inactivated at about 83° C.; that of ordinary tomato mosaic at about 90° C. in these experiments. "Streak" is induced when healthy tomato plants are double-inoculated from tomato plants with yellow mosaic and from potato plants.

Evidence regarding the shape of tobacco-mosaic-virus particles. WILLIAM N. TAKAHASHI and T. E. RAWLINS.

If a liquid containing small rod-shape particles flows from a small tube the entire stream should exhibit form double refraction; if the liquid is sucked from a beaker into the tube the flowing doubly refractive liquid in the beaker should exhibit a dark cross. A liquid containing small discs or leaf-shape particles should show form double refraction only near the margins of the stream and no double refraction or dark cross when sucked from a beaker into a tube.

Sols, the particle shape of which had been determined by Freundlich and associates by the application of the Tyndall phenomenon, were expelled from and drawn into a

small tube as described above; all sols tested exhibited the expected double refraction phenomena, thus confirming the above hypotheses. Tobacco-mosaic virus exhibited the double refraction characteristic of sols containing rod-shape particles; juice from healthy plants exhibited no double refraction.

Preliminary studies have indicated that the particles in the infective tobacco juice that cause the double refraction have size and precipitation properties characteristic of the virus. The available evidence, therefore, indicates that tobacco-mosaic virus is composed of rod-shape particles.

Comparative studies of two loose smuts of barley. V. F. TAPKE.

Stilbum cinnabarinum, the cause of a new fig disease in Louisiana. E. C. TIMS.

In May, 1932, diseased fig branches were received from Ascension Parish, Louisiana. These twigs were covered with small reddish pink fungous heads borne on short synnemeta. The heads consisted of masses of small, hyaline, unicellular conidia, from which pure cultures were easily obtained. Inoculations made in young fig branches through small wounds developed the typical fungous heads 20 days later. The fungus spread rapidly through the woody tissues of the twig and into the pithy center. A number of the inoculated twigs had been killed back to the 2-year-old wood after 30 days. The fungus was reisolated, and numerous inoculations established its parasitism. The fungus causing this twig blight of fig has been identified as *Stilbum cinnabarinum*. Observations made during the summer of 1932 show that the disease is wide-spread over southwestern Louisiana, on the Celeste fig, but apparently causes only minor damage under most conditions.

Leptosphaeria salvinii, the ascigerous stage of Sclerotium oryzae. E. C. TULLIS.

In the summer of 1931 an ascomycete belonging to the genus Leptosphaeria was found on rice plants in the greenhouse at Fayetteville, Arkansas. The fungus proved to be *Leptosphaeria salvinii*. The same fungus was found on 16 different varieties of rice at the Rice Branch Experiment Station near Stuttgart, Arkansas. Cultures from ascospores in the winter and spring of 1931–32 produced sclerotia typical of *Sclerotium oryzae* and conidia typical of *Helminthosporium sigmoideum*. Rice plants were inoculated with sclerotia from colonies originating from ascospores. Perithecia, conidia, and sclerotia were produced on these plants. Thus, the genetic connection between these three stages has been established by cultural and inoculation experiments. (Cooperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Arkansas, Louisiana, and Texas agricultural experiment stations).

Further purification of the virus of tobacco mosaic. CARL G. VINSON.

Progressively increasing the amount of a safranin solution added to a given amount of juice from diseased plants results in a progressive decrease in concentration of virus remaining in the supernatant liquid.

The virus may be reprecipitated with safranin without appreciable loss of virus being demonstrable.

When two volumes of acetone are added in the cold to one volume of the virus fraction obtained on decomposing the safranin precipitate, a precipitate forms; but considerable virus seems to remain in the supernatant liquid.

Comparative studies of peas resistant and susceptible to Fusarium wilt. J. C. WALKER.

Resistant and susceptible strains of Alaska were used. Plants were grown for various intervals at about 15° C. in Tottingham's solution, to which was added, after plant removal, 1 per cent dextrose. The pea-wilt fungus, *Fusarium orthoceras* var. *pisi*, was grown on aliquot portions of the autoclaved solutions. There was observed very consistently a heavier growth in the solution in which the susceptible roots had grown. In autoclaved extracts from fresh susceptible roots there was a slightly heavier growth than in those from resistant roots. In extracts from air-dried roots a similar slight difference was obtained. In extracts from roots dried at 85° C. there was a markedly heavier growth in those from susceptible roots.

Relation of soil fertility to incidence of Aphanomyces root rot of pea. J. C. WALKER.

Colby silt loam is one of the most favorable Wisconsin soils for the development of this disease. Eight canning varieties were tested in the greenhouse on this type of soil from a heavily infested field. All were severely damaged by root rot. When a 500-lb. application of 4–16–4 fertilizer was added to a portion of this soil there was a marked reduction in the severity of the disease. In the Alaska variety 63 to 100 per cent of the plants were severely infected in the nonfertilized soil, while 3 to 20 per cent were so affected in the fertilized soil. Surprise, Bruce, Admiral, Ashford, Perfection, Prince of Wales, and Wisconsin Early Sweet reacted in a similar manner.

Nectria canker of basswood. D. S. WELCH.

Cankers have been found seriously affecting the basswood, *Tilia americana*, in native stands in central New York. On 2 half-acre plots selected at random there were 258 trees, 117 of which bore cankers of the type commonly associated with Nectria infections on other trees. The lesions are sunken in the center and a number of concentric callus rolls marks the age of the infection. A species of Nectria has been repeatedly isolated from infected tissue at the margin of the cankers and from conidia and perithecia occurring on affected tissue. Basswood trees of various ages have been inoculated with positive results in 54 out of 64 trials. All 7 checks remained healthy. The same organism has been reisolated several times from such infections 18 to 24 months after the date of inoculation. Stromata bearing conidia and perithecia are produced sparingly at the margins of cankers on living trees. On infected trunks that have been cut and left in the woods the fungus develops in great abundance. On such trees perithecia containing viable spores may be found every month throughout the year. Similar diseases, apparently hitherto unreported, have been found on *Acer rubrum*, *A. spicatum*, *Fraxinus nigra*, *Populus grandidentata*, *Prunus serotina*, and *Rhus typhina*.

Relation of cranberry varieties to the spread of false blossom. R. B. WILCOX.

The severity and rate of spread of false blossom in a cranberry-growing region are related somewhat to the proportion of the total acreage devoted to resistant varieties. In New Jersey there have been, during the past decade, wide differences between varieties as to losses suffered. A quick and convenient method has been developed that seems to test accurately the resistance of a variety to the spread of false blossom.

Bacterial canker of Prunus spp. in California. E. E. WILSON.

A disease in California that has been regarded as the "bacterial gummosis" described in Oregon by Griffin and Barss may be produced by two types of bacteria that differ in chromogenesis and possibly in temperature requirements but are similar in

most other characters. In the pathogenicity and cultural tests so far attempted one of these organisms agrees in most characters with those described for *Pseudomonas cerasi*. The other appears to be a strain of *Ps. cerasi*. In comparative tests, this strain and *Ps. prunicola*, the latter recently described by Wormald, from England, differed only in size.

The cankers of the disease are quiescent during most of the summer but begin to extend at about the time of leaf fall in the autumn. This activity continues throughout the winter and early spring but wanes soon after the trees come into leaf. While temperature is found to influence the rate of canker extension, it apparently is not the only cause of this seasonal variation in activity. Evidence obtained by inoculating plums throughout the autumn, winter, and spring suggests that the host itself may influence canker extension.

Development and control of olive knot. E. E. WILSON.

Olive knot has become serious in the northern part of the Sacramento Valley within the last 4 years. It is found on trunks, limbs, smaller branches, leaves, and occasionally on fruits. It occurs most abundantly on the smaller branches.

In certain orchards 95 per cent of the knots develop at leaf or blossom scars. The time of leaf fall and the variations in the amount of leaf fall from growth of different age and from trees of different vigor have been studied with respect to their effect on leaf-scar infection.

Through inoculations it was determined that, although infection may take place in December and January, the knots may not appear until March or April. On the other hand, inoculations made in March and April developed knots within a few weeks. The same situation was reflected in the development of knots resulting from natural infection, inasmuch as nearly all knots appeared in the spring and early summer.

Control has been attempted through application of the following materials as sprays: lime sulphur, sodium fluosilicate, zinc sulphate lime, commercial Bordeaux with an oil emulsion, and homemade Bordeaux. The latter material gave promise when it was used in 3 applications. The other materials gave varying degrees of control but were, on the whole, unsatisfactory.

Influence of spray materials on transpiration. J. D. WILSON and H. A. RUNNELS.

Bordeaux mixture checked growth, decreased yield, and increased transpiration and blossom-end rot of tomatoes, whereas none of these conditions obtained in an oil spray. Experimental data collected to date indicate that the following relations probably exist: (1) Transpiration is accelerated by Bordeaux mixture more during the night than the day period. (2) Certain other copper sprays do not cause increases in transpiration comparable with Bordeaux mixture. (3) If the quantity of copper in a given volume of Bordeaux mixture is held constant, each additional increment of lime increases the influence of the mixture on the transpiration rate until the quantity of lime becomes about 1½ times as great as that of the copper. (4) Bordeaux mixtures made up with high magnesium and with high calcium limes are equally effective in increasing transpiration. (5) A mixture of hydrated lime and water is not so effective as a Bordeaux mixture containing an equivalent amount of lime. (6) Mixtures in which the particles remain well in suspension are more effective than those in which settling occurs quickly. (7) Certain other sulphates in combination with hydrated lime are as effective as copper sulphate.

Use of formaldehyde dust with vegetable seedlings. J. D. WILSON and P. E. TILFORD.

Formaldehyde dust has been found to improve the stand of seedlings in those soils in which damping-off occurs if no precautions are taken to prevent it. When the 6 per cent dust is mixed with the soil at the rate of 8 oz. per bu., damping-off is controlled and formaldehyde injury to the seeds themselves is rare. If the dust is placed in the seed row at the rate of 1 gm. per linear ft., the stand of certain vegetables, especially spinach and beets, is improved, whereas such plants as the crucifers are injured by the formaldehyde.

Formaldehyde is least toxic when adsorbed on inert carriers of low weight per unit of volume, such as infusorial earth and finely divided charcoal. Injury to seeds is greatest in heavy soils and those low in organic matter. Also, injury is greatest at medium soil-moisture content. It has been found that in most cases seedlings cannot be transplanted into treated soil until at least 72 hours after treatment. Formaldehyde escapes more quickly from dry and warm soils than from cold and wet ones. If transplanting is done immediately after treatment, less injury occurs in soils of high absorptive capacities, such as muck.

Nature of rust resistance in beans. S. A. WINGARD.

Bean varieties differ markedly in their response to rust and may be grouped roughly into 3 classes on the basis of their reaction to infection. (1) Varieties that are immune, showing no evidence of infection; (2) those that show severe flecking as a result of infection; and (3) those on which numerous fertile sori are produced. The varieties in the first group show true resistance; those in the second and third groups are susceptible. The flecking varieties (Group 2) are hypersensitive to rust infection, and, as a result, the rust fungus immediately kills the invaded tissues upon entering the leaf and thereby sets up a condition detrimental to the further development of the fungus. In the third group the rust fungus and host tissues seem more compatible and are thus able to endure each other. In this group there is evidence that the rust fungus acts even as a preservative for the invaded tissues of the host. This is shown by the fact that the region immediately surrounding the sorus is the last part of the leaf to lose its chlorophyll and die.

Intracellular bodies in ring spot. MARK W. WOODS.

Intracellular bodies, similar to those in tobacco mosaic, have been found in ring spot. They were found in primary and systemic lesions in *Nicotiana tabacum* var. Turkish and in primary lesions in *N. tabacum* var. Havana Seed-Leaf, *N. rustica*, *N. glutinosa*, and Petunia. Best results were obtained after fixation in formol-acetic alcohol and staining with Fleming's triple stain. The bodies appeared typically granular in structure, vacuolate, and with or without membrane-like surfaces. In Nicotiana they sometimes contained minute red cuboidal inclusions. Similar cuboidal bodies were also found in the cytoplasm and nuclei of diseased and healthy cells. They appear to be similar to cuboidal structures observed by certain workers in mosaic-diseased and healthy tobacco plants. Intracellular bodies were found in cells of the mesophyll, epidermis, and trichomes. The development of intracellular bodies seemed to be directly related to the formation of visibly lesioned areas in the leaf. Bodies were never found in normal-appearing regions of diseased or healthy leaves. Intracellular bodies as large as the nucleus were observed in lesions 5 days after inoculation, but bodies were more commonly found in older lesions. Tests with Turkish tobacco and *N. glutinosa* apparently demonstrated that no virus other than that of ring spot was present in plants in which intracellular bodies were found.

Sclerotinia stem canker of hollyhock. PAUL A. YOUNG.

A fungus with the characters of *Sclerotinia libertiana* was isolated in 1931 from stem cankers in hollyhock, *Althaea rosea,* in Bozeman, Montana. In 1932 it was inoculated into wounds in hollyhock and White Beauty sunflower, *Helianthus annuus,* stems growing in a field plot. It caused many cankers within 13 days and killed the infected stems within 60 days. Seventy-one of the 84 hollyhock inoculations and 21 of the 27 sunflower inoculations caused cankers. *Sclerotinia libertiana* was reisolated from the hollyhock and sunflower cankers. Only the sunflower cankers spread into the roots during the summer. The sunflower cankers were like those described in Montana Bulletin 208. The hollyhock cankers from natural and artificial inoculations were white, 5 to 45 cm. long, and usually encircled the stems. Many cankers had black margins and bore 1 to 4 brown, concentric arc lines each about 1 by 10 mm. The arcs often marked epidermal wrinkles. Black streaks occurred in the epidermis and wood near some cankers. Black sclerotia occurred in cavities formed in the stem pith. Sclerotia occurred on cankers in hollyhock stems that had been under snow.

Soil infestation by chlamydospores of Tilletia levis in Montana. PAUL A. YOUNG.

Seed wheat, surface sterilized with formaldehyde, was planted by scattering from envelopes into 3 m. rows at about 10-day intervals on 4 dates in September and 3 dates in October, 1931. The rows were in 4 fallowed plots in a region 4 km. square near Menard. The rows were within 10 to 50 m. from one of six 50- to 300-acre-wheat fields, combine-harvested in August, 1931, in which 12 to 50 per cent of the heads were bunted by Tilletia. Wheat planted before October 6 emerged within 15 to 30 days. Soil infestation by Tilletia caused the following average percentages of bunted heads in the following varieties of wheat planted in September, 1931: Turkey, 11.9; Oro, 0.8; Regal, 0.9; Kharkof, 2.7; Sherman, 0.6; Ridit, 0.2; Hybrid 128, 12.5; Albit, 0.2; Hussar, 0.2; Kanred, 12.1; Montana 36, 20.0; and Jones Fife, 21.9. The Tilletia (*T. levis*) concerned probably was physiologic form 3 of Oregon Bulletin 281. Smutted Montana 36, planted as checks, averaged 65 per cent bunt. Soil infestation by Tilletia decreased rapidly in October, becoming 0.

(Cooperative investigation between the Botany Department of the Montana Agricultural Experiment Station and the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture).

Transmissibility of certain legume-mosaic viruses to bean. W. J. ZAUMEYER.

Cross-inoculation experiments have shown that the viruses causing mosaic diseases of several legumes are capable of being transmitted to beans. The viruses causing mosaics of white sweet clover, *Melilotus alba,* yellow sweet clover, *M. officinalis,* white clover, *Trifolium repens,* and alsike clover, *T. hybridum,* gave positive results when inoculated to beans. A mosaic virus from red clover, *T. pratense,* gave negative results.

The virus of the mosaic of white sweet clover produced symptoms on beans slightly different from those of the common bean mosaic. It is possible that some of the secondary spread of bean mosaic in the field is the result of aphid transmission from the white-sweet-clover-mosaic virus.

The virus of the mosaics of pea, *Pisum sativum,* and of sweet pea, *Lathyrus odoratus,* gave positive results when inoculated into beans, either by means of expressed juices from diseased plants or by the pea aphis, *Illinoia pisi.*

Transmission of bean-mosaic virus by insects. W. J. ZAUMEYER.

Insect-population studies in bean fields in Colorado, Idaho, and Virginia, conducted for the past few years by the Bureau of Plant Industry and the Bureau of Entomology of the United States Department of Agriculture, have shown many species of insects present that, with the exception of aphids, proved incapable of transmitting bean mosaic.

Various species of aphids whose number depends on the season and the locality are always present on beans in the field. The greatest population occurs at the early part of the growing season.

Under controlled greenhouse conditions, the virus has been transmitted by feeding virus-free aphids on mosaic-infected beans for 24 to 30 hours and then transferring the insects to healthy plants. In addition to the potato aphid, *Illinoia solanifolii*, the bean aphid, *Aphis rumicis*, and the peach aphid, *Myzus persicae*, shown by other investigators to be vectors, the following aphids will also transmit the virus: the pea aphid, *I. pisi*, the cucumber aphid, *A. gossypii*, the cabbage aphid, *Brevicoryne brassicae*, the Chenopodium aphid, *Hyalopterus atriflicis*, and an aphid, *Macrosiphum ambrosia*, common on wild Compositae. All these species except *M. ambrosia* have been found on beans in the field. (Aphid determinations made by P. W. Mason, Bureau of Entomology.)

STUDIES ON CERTAIN ENVIRONMENTAL RELATIONS OF THE ROOT-KNOT NEMATODE, HETERODERA RADICICOLA[1]

G. H. Godfrey and Helene Morita Hoshino

(Accepted for publication April 4, 1932)

Information on environmental relations of a plant-parasitic organism is fundamental to control. Upon attacking the problem of nematode control in connection with pineapple culture in Hawaii, it was evident that specific information was lacking concerning the relations of environment to survival of eggs and larvae of the root-knot nematode, *Heterodora radicicola* (Greef) Müller. This paper contains the results of specific studies on this problem, a brief preliminary report of which has already been made (10). The portion dealing with high-temperature relations, being a unit by itself, is reported in a separate paper (13).

The specific studies reported in this paper were stimulated by indications in the literature and from various observations and exploratory experimental work that the root-knot nematode is very highly susceptible to injury by adverse environmental conditions. In a preliminary experiment conducted at Washington, D. C., some years ago, this was strikingly shown. The soil surrounding the roots of a badly root-knotted begonia plant was divided into 3 equal portions, which were treated as follows: (1) exposed in a layer about 1 in. deep to July sun for 6 hours (10:00 a. m. to 4:00 p. m.); (2) same treatment, then remoistened, and the exposure repeated on a 2nd day; (3) held in the laboratory unexposed and continuously moist. All 3 lots were then set to small tomato plants previously grown in sterilized soil. In about 3 weeks, examination of these plants revealed that plants *1* and *2* were entirely free from infection, whereas plant *3* was heavily knotted. Definite complete killing of the nematodes in the soil, in all stages, had resulted from even the few hours' exposure of but one day. Killing was due to one or more of the three factors, heat, drying, and light. This result and the results of other exploratory experiments and literature reports indicated the desirability of determining the extent to which each of these factors, temperature, drying, and light, was capable of contributing to the mortality of nematodes in controlled life-history stages. The present paper has to do with humidity relations and with the effects of light.

Most of the contributions to the literature on this subject are very general in nature. Specific papers are cited in the introductory paragraph to each phase of the subject considered.

[1] Published with the approval of the Director as Technical Paper No. 37 of the Experiment Station of the Association of Hawaiian Pineapple Canners, University of Hawaii.

CULTURE METHODS

Eggs and larvae were obtained readily, as desired, by the methods described in another paper (9).

Death of the larvae was manifested by lack of movement, and by failure to recover motility within a week, during which period conditions were favorable for life. The greatest certainty of such favorable conditions was obtained in shallow, well-aerated drops of tap water exposed to the air, though larvae in beakers of water in the ice box at about 10° C. remained alive and active for 2 weeks or longer. Drowning is a possibility, however, particularly in water from which air has been exhausted. Dead larvae lie normally in a very typical extended or slightly bowed position (Fig. 1).

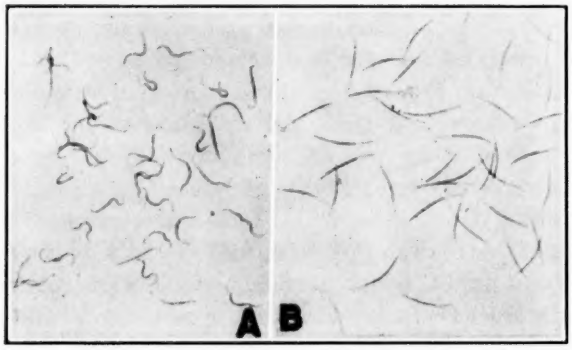

FIG. 1. *Heterodera radicicola* larvae. A. In the attitude of normal activity and B. In the attitude of death.

When all the larvae of a treatment are in this condition and do not recover movement within a few days, it is reasonably certain they are dead. In some of the tests further trials of doubtful material were made by using it as inoculum on the roots of highly susceptible cowpea plants growing in sterilized soil. If no knots developed, it was considered that there were no living larvae in the inoculating material. As the readings by observation always checked with inoculation readings, the latter were eventually eliminated.

Similar tests with eggs demanded that they hatch under favorable conditions within 30 days in order to be considered alive. Extensive tests were made to determine most favorable conditions for this viability test. Byars (3) placed eggs on plates of agar and observed presence or absence of larvae, with no particular count of percentage of hatch. McClintock (14) conducted tests on the effects of various chemicals on eggs by transferring treated egg masses to test-tubes containing synthetic-nutrient agar. After trying similar media we discarded agar in favor of the simpler

TABLE 1.—*Percentage of untreated eggs hatched at room temperature (24–28° C.)*

Lot No.	No. of egg masses	Total No. of eggs	Av. eggs per egg mass	Percentage of total eggs hatched at successive time intervals (days)							Percentage total hatch
				2	4	8	12	16	20	24	30	
1	6	1,738	290	5.29	10.24	28.94	45.05	7.07	0.11	0	0	96.3
2	6	1,410	235	7.80	9.78	33.26	32.90	12.12	0.56	0.07	0	96.5
3	12	6,254	521	14.16	17.39	24.83	23.88	16.45	0.67	0.46	0	97.7
4	12	5,228	436	25.24	27.90	34.18	9.04	2.37	0.01	0	0	98.7
5	12	4,704	392	28.23	20.79	21.68	28.08	0.14	0.02	0	0	98.9
6	12	3,719	310	36.19	30.43	22.64	3.14	0.16	0.10	0	0	95.5
7	10	4,856	486	30.91	34.67	23.02	9.08	1.07	0.24	0	0	99.0
8	4	2,977	744	10.21	10.71	12.59	46.38	17.03	2.21	0	0	99.1
9	10	4,085	409	2.76	7.90	16.59	41.90	26.56	1.66	0	0	97.4
Averages			416	20.02	21.16	23.86	23.24	8.88	0.58	0.09	0	97.8

method of drops of water on slides held at room temperature. It was found that hatched larvae migrated readily out of the egg mass and moved freely in the bottom of the drop. By transferring the egg mass to a new drop daily it was possible very readily to count the larvae and thus determine the daily hatch. A daily change of water was found advisable, as these nematodes are quickly killed by pollution.

Time required for hatching under average conditions and percentage of total number of eggs hatched in 1 series of tests are reported in table 1. Obviously this table applies only to this particular series. Rate of hatching depends very much upon the temperature. Under somewhat warmer conditions, the time required for complete hatching may be shorter, other conditions being the same. No attempt was made to control the age of egg masses. It is obvious from the results that, with some, the embryonic stages of cell division and multiplication were already well advanced.

Incubation conditions were maintained for 30 days, at the end of which period no further hatching had occurred for 4 to 6 consecutive days. In every lot at least 96 per cent of the eggs hatched. In several plates a 100 per cent hatch was obtained.

In addition to being a reliable method for testing viability of eggs, this preliminary work gave information on the egg-producing capacity of the root-knot nematode. In our test, as shown by table 1, the majority of the eggs had hatched by the 8th day of incubation; nearly all were hatched by the 16th day, which is somewhat faster than the time reported by Frandsen (5), 20 to 28 days. Other studies revealed individual instances of very high numbers of eggs within an egg mass, counts having been made of 1,052, 1,154, 1,277, and 1,308 in individual egg masses. The average number in this lot of 84 egg masses was 416 eggs per egg mass. Other figures reported have been 300 to 500 by Frandsen (5) and Childs (4) and 100 to 200 by Atkinson (2).

THE EFFECT ON THE VIABILITY OF EGGS AND ON THE LIFE OF THE LARVAE WHEN EXPOSED TO DIFFERENT PERCENTAGES OF RELATIVE HUMIDITY

Stone and Smith (19) stated that neither larvae nor eggs can stand desiccation, but no actual data on its effect were presented. Frandsen (5) reported that nematodes are resistant to cold but lack resistance to drying. Eggs and larvae placed on a glass slide and allowed to dry for a few minutes failed to show any signs of further development and, if infected roots and tubers were allowed to dry thoroughly, all the eggs and larvae in them were killed. Spaulding and Gravatt (17) tested the influence of physical factors, particularly drying, upon the viability of the sporidia of the white-pine-rust fungus, *Cronartium ribicola* Fischer, and reported that the viabil-

ity was decreased merely by bringing them to air-dried condition. They used desiccators, in which the relative humidities were controlled by using different concentrations of sulphuric acid, to study the effect of prolonged drying. They pointed out that the injury to the sporidia from exposure increased with the decrease in the relative humidity.

Methods. To determine the effects of drying alone on nematodes, it was necessary to maintain noninjurious light and temperature conditions. All tests were conducted in the laboratory free from direct sunlight, hence the light factor was eliminated. Room temperature (about 20 to 28° C.) shows no injurious effect upon the life of the larvae or on egg viability.

In order to control the relative humidity, technique similar to that employed by Spaulding and Gravatt (17) was followed. Scheibler desiccators of approximately 5,000 cc. total capacity were used. Sulphuric acid of 1.84 specific gravity was used in making up the solutions that would produce the following relative humidities: 50, 60, 70, 80, and 90 per cent. Stevens (18), the Handbook of Chemistry and Physics (12), and the Smithsonian Tables (16) were consulted in preparing these solutions. Density was ascertained with hydrometers. Four hundred cubic centimeters of each solution were put in the base of each desiccator. This amount of acid was used because it presented a maximum surface area for the most rapid action on the air, and with such a volume the density of the acid changes very little by the water taken up from the air of the chamber. As soon as the acid solution was put in the desiccator, the cover was sealed with vaseline and the chamber placed in a dark room where the temperature was fairly uniform. The acid was poured into the chambers 24 hours before the beginning of a test, so that the relative humidity of the air could reach equilibrium. A 100 per cent moisture condition was obtained by pouring 400 cc. of distilled water, instead of acid, into the desiccator. In making the test with larvae, 100 freshly hatched active larvae were first placed in a small drop of water on each slide and left in the laboratory for preliminary drying. As soon as the slide looked dry to the unaided eye, it was examined for water under a microscope. If no free water was detected and if all the nematodes were still moving about, the slide was immediately used for exposure. Several control slides of larvae that were thus dried in a preliminary way were put under favorable moisture conditions by adding a drop of water to each, and it was found that not a single nematode had been killed. Egg masses previously taken from roots and placed in water were dried on filter paper and placed on slides ready for exposure. For studies on free eggs, egg masses were dissected under the microscope and the freed eggs pipetted into drops of water on a slide, 100 to a slide. The slide bearing the eggs or larvae was

TABLE 2.—*Effect of exposure to different percentages of relative humidity on the life of the larvae and on egg viability*

Relative humidity percentage	Larvae		Eggs in masses		Eggs free	
	Time of exposure	Percentage killed	Time of exposure	Percentage killed	Time of exposure	Percentage killed
50	30 sec.	17	15 min.	12.02	15 min.	20.9
	1 min.	34	30 "	21.65	30 "	49.7
	3 "	94	1 hr.	98.4	1 hr.	99.2
	4 "	100	1½ "	94.2	1½ "	100.0
			2 "	99.0	2 "	100.0
			2½ "	100.0		
			3 "	100.0		
60	30 sec.	5	30 min.	2.84	15 min.	15.4
	1 min.	30	1 hr.	95.4	30 "	46.7
	3 "	77	1½ "	97.9	45 "	86.9
	5 "	100	2 "	98.8	1 hr.	96.4
			2½ "	99.8	1½ "	98.7
			3 "	100.0	2 "	99.3
					2½ "	100.0
					3 "	100.0
70	30 sec.	3	30 min.	1.4	30 min.	25.3
	1 min.	9	1 hr.	21.1	1 hr.	50.1
	3 "	26	1½ "	25.6	1½ "	51.4
	5 "	30	2 "	88.0	2 "	94.1
	7 "	56	2½ "	88.6	3 "	100.0
	8 "	86	3 "	99.8	4 "	100.0
	10 "	100.0	4 "	100.0		
	12 "	100.0				

TABLE 2—(*Continued*)

Relative humidity percentage	Larvae		Eggs in masses		Eggs free	
	Time of exposure	Percentage killed	Time of exposure	Percentage killed	Time of exposure	Percentage killed
80	30 sec.	2	30 min.	0.1	30 min.	7.5
	1 min.	3	1 hr.	1.5	1 hr.	44.1
	5 "	13	1½ "	16.1	1½ "	49.3
	8 "	60	2 "	73.6	2 "	80.1
	10 "	90	3 "	92.0	3 "	98.4
	12 "	92	4 "	92.8	4 "	100.0
	15 "	100	5 "	100.0	5 "	100.0
	20 "	100	6 "	100.0		
90	30 sec.	0	30 min.	0.2	30 min.	2.8
	1 min.	0	1 hr.	2.0	1 hr.	12.4
	5 "	2	1½ "	1.6	1½ "	43.1
	10 "	9	2 "	2.4	2 "	45.6
	12 "	12	3 "	6.2	3 "	49.2
	15 "	13	4 "	20.0	4 "	87.0
	20 "	28	5 "	21.4	5 "	99.8
	30 "	100	6 "	30.0	6 "	100.0
			7 "	98.0	7 "	100.0
			8 "	98.6		
			9 "	100.0		
100	24 hr.	0	6 hr.	0.2	8 hr.	0.9
			7 "	0	24 "	1.4
			10 "	0.5		
			24 "	1.3		

placed on the perforated porcelain plate in the container. It was inserted or taken out of the desiccator in less than 2 seconds.

After the completion of a series of tests, the density of the solution was again determined with a hydrometer. There was no observable variation in the desiccators during the experiment. Each treatment was replicated 3 times. Unexposed slides of larvae and eggs were kept in the laboratory in Petri dishes lined with moist filter paper to serve as controls.

Results and Discussion. The effects of exposure to different relative humidities on the life of the larvae and on egg viability are presented in table 2. In bold-face type in this same table can be seen, under each humidity, the shortest period at which all the nematodes were killed.

Table 2 shows that there was an increase in the number of larvae killed and in the injury to egg viability as the percentage of relative humidity decreased. Also, increase in length of time of exposure increased the in-

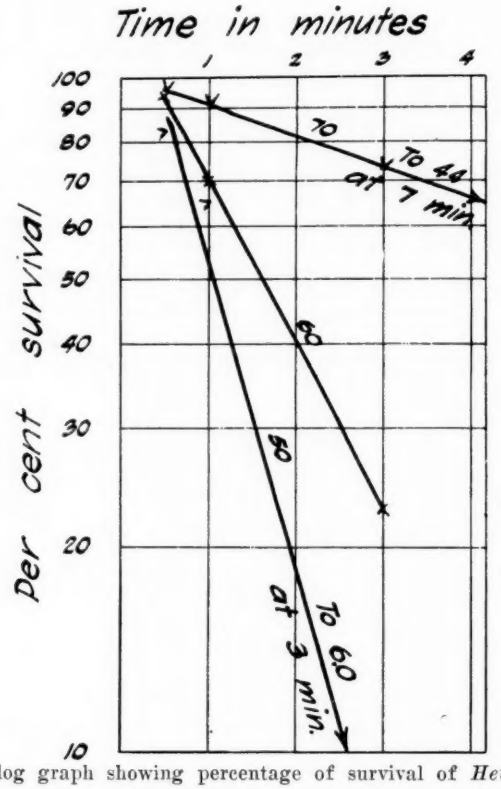

FIG. 2. Semilog graph showing percentage of survival of *Heterodera radicicola* larvae at 50, 60, and 70 per cent relative humidity. Note the relatively straight-line relationship between time and percentage of survival. Note also that at the lower humidities the rate of killing is more rapid than at the higher.

jurious effect. Relative humidity of 100 per cent completely failed to kill the larvae or injure the viability of the eggs. The data for egg masses at this humidity show a consistently high percentage of hatching. With lower humidities a longer time was required to kill the eggs than was required for the larvae; likewise a longer time was required to kill in egg masses than to kill free eggs.

The striking fact is evident from table 2 that even under relatively high humidity conditions (90 per cent) only a comparatively short period of time is required to kill even the more resistant stage (egg stage) of the nematode. Under average summer *air* conditions in Hawaii, approximately 70 per cent relative humidity, hatched larvae are killed in only 10 minutes, eggs in egg masses in 4 hours, and free eggs in 3 hours.

One phase of the results of table 2 is presented in another form in figures 2 and 3, which are semilog graphs showing the relatively straight-line relationship between time and percentage survival in larvae and in

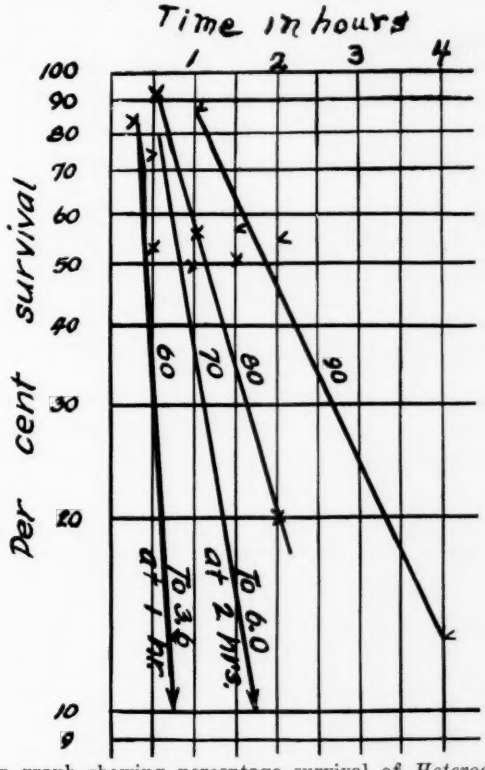

FIG. 3. Semilog graph showing percentage survival of *Heterodera radicicola* free eggs at different relative humidities for different time intervals. The story here is much the same as that shown for larvae, except that the rate of killing is much slower.

free eggs, respectively. The results with eggs in egg masses were too irregular to show such straight-line relationship, which is readily accounted for by the irregularity of the protective material of the egg mass. The degrees of slope shown by the lines in each graph as a unit indicate relative rates of killing with the different degrees of humidity. The more rapid killing at the lower humidities is readily seen. Figures 2 and 3 are not to be compared in this respect, since in the one time is plotted in minutes whereas in the other it is in hours.

THE EFFECT ON EGG VIABILITY AND ON LARVAE WHEN EXPOSED TO COMPLETE DRYNESS FOR DIFFERENT PERIODS

Methods. In performing this test, favorable light and temperature conditions were maintained. The experiments were conducted in a dark room at room temperature. Preliminary steps were identical with those followed in the tests of different degrees of relative humidity; the organisms were allowed to stand under laboratory conditions until visible free water had evaporated before they were placed in the (practically) completely dry environment, which was maintained in a desiccator by means of concentrated sulphuric acid. The desiccator was sealed with vaseline and tests conducted in the same manner as in the previous experiment. Dehydration of the organisms began, of course, immediately after the vessels were sealed.

Experimental. The larvae were exposed to complete drying for the following periods: 10 to 45 seconds and 1 to 5 minutes. The egg masses were tested for from 5 to 30 minutes and 1 to 3 hours. Table 3 indicates that exposure to complete dryness for even the brief period of 10 seconds had some injurious effect upon the life of the larvae. In 3 minutes, every

TABLE 3.—*Effect of complete drying for different periods on Heterodera radicicola*

Larvae		Eggs in masses		Eggs free	
Time of exposure	Percentage killed	Time of exposure	Percentage killed	Time of exposure	Percentage killed
10 sec.	4	5 min.	6.0	10 min.	24.2
15 "	15	10 "	9.0	15 "	50.1
30 "	25	15 "	12.4	30 "	99.6
45 "	36	20 "	14.8	45 "	99.8
1 min.	49	30 "	98.4	1 hr.	100.0
2 "	83	1 hr.	98.7	1 " 30 min.	100.0
3 "	100	1 " 30 min.	98.1		
4 "	100	2 "	100.0		
5 "	100	2 " 30 min.	100.0		

larva was killed. The eggs were not killed until after a much longer period of exposure. After 30 minutes, nearly all (98.44 per cent.) were killed, but it took an exposure of 2 hours to kill every 1 in all egg masses. The irregularity in degree of protection offered by the gelatinous matrices in different oothecae is manifest here. Free eggs were killed in 1 hour.

EFFECT ON EGG VIABILITY AND LIFE OF LARVAE WHEN EXPOSED TO SUNLIGHT AND TO LIGHT FROM A MERCURY VAPOR LAMP

The literature on effects of ultra-violet radiation on various organisms is too great to mention, except very superficially, in this paper. Much has been done on its lethal effects on various pathogenic bacteria. Spaulding and Gravatt (17) report that solar radiation, with the heat and drying factors controlled, quickly kills nearly all the exposed sporidia of *Cronartium ribicola*. Fulton and Coblentz (8) did some careful work with ultra-violet on fungi of various kinds. Sheard and Hardenbergh (15), studying the effects of ultra-violet on *Demodex folliculorum* of dogs, report that irradiation by the mercury vapor lamp at 25° C. at a distance of 50 cm. is fatal in 15 to 30 minutes. No reports of investigations have been found by the writers on the eggs or larvae of *Heterodera radicicola*. Freer (6) reports killing of nematodes, without referring to the kind, after 2 or 3 minutes' exposure to the sun. Watson (20) reports that hot sunlight is very injurious to soil organisms in general.

Methods. The technique used in the study of effects of ultra-violet on *Heterodera radicicola* was suggested by that employed by Lois Godfrey (11) in her studies on the measurement of ultra-violet in Hawaii sunlight. Some of the apparatus used in our studies was supplied by her. During the course of any specific exposure, favorable temperature and moisture conditions were maintained. Slides, each containing a fresh egg mass or 100 active larvae in a drop of water, were placed in a dish lined with moist filter paper and covered with a quartz glass top that is penetrable by ultra-violet. (It is well known that ordinary laboratory glass absorbs all except the longest wave lengths of the ultra-violet of the spectrum).

Such dishes were exposed to the sun usually on bright, clear days for various periods of time. Similar slides bearing larvae and egg masses were exposed to ultra-violet radiation for various periods of time. The source of radiation employed was a Cooper-Hewitt, air-cooled, quartz mercury vapor lamp operated at 110 volts, exposure being at a distance of 50 cm.

A dark glass known technically as "Corex red purple" (Corning Glass Company No. G. 986A), known to exclude practically all the solar rays except the ultra-violet and transmitting an average of about 60 per cent. of that throughout its range, was also used, instead of the quartz glass cover,

with both the larvae and egg masses, exposed to sunlight and to the mercury vapor lamp. The object of using this dark glass was to test whether or not ultra-violet, alone as a factor, is capable of bringing about lethal effects upon the nematodes.

Experimental. Before exposing the larvae and eggs to the sun, elimination of the heat of sunlight as an injurious factor had to be considered. The larvae and eggs were exposed on separate drops of water about ½ mm. deep on slides placed in Petri dishes lined with moist filter paper. The constant addition of water to the drop on the slide prevented the water from heating up to a temperature higher than 30° C. Not a single nematode subjected to a temperature of 35° C. for 4 hours in a separate experiment on heating effects was killed. Hence, the drop of water and also the low temperature eliminated the heat and drying factors. Simultaneous exposure under identical conditions with regular glass Petri dish covers, instead of quartz covers, showed no killing of larvae even after several hours, which would seem to eliminate heat as a factor, since glass is penetrable to heat but not to ultra-violet.

As a still further check on the temperature factor, a series of 3 slides, each containing 100 fresh, active larvae in a drop of water, was placed upon a flat tray of ice and exposed to the sunlight for the same periods of time. The results in percentage killed were not perceptibly different from those obtained from the usual method of exposure. Separate tests had shown that actual freezing of the water containing Heterodera larvae over ice and salt did not kill them, even when freezing was repeated several times with the same lot of material. Cold, therefore, was not a factor in killing.

Exposures in Petri dishes without covers as compared with those with quartz glass covers gave no perceptible difference with regard to the effect of the ultra-violet rays. Several preliminary experiments determining this point were carried out with approximately the same results. This is to be expected since quartz is completely transparent to solar radiation.

The series of experiments was repeated 6 times. The average results obtained are presented in tables 4 and 5.

Subjection of larvae to ultra-violet radiation by exposure to sunlight for 25 minutes killed all the larvae. Irradiation by the mercury vapor lamp killed them after exposure for 12 minutes. With eggs, a longer time was required to produce any killing effect. When exposed to sunlight it took 5 hours, and when exposed to light from a mercury vapor lamp, 4 hours to kill every egg in the egg mass. The time required for killing free eggs, however, was considerably shorter. It would seem definitely that the material of which the gelatinous matrix of the egg mass is composed serves to some degree as a protection against the penetration of ultra-violet rays.

TABLE 4.—*Effect of different periods of exposure to light on the life of larvae*

Time of exposure		Percentage killed			
		Exposure to sunlight		Exposure to light from mercury vapor lamp	
Hours	Minutes	Under quartz glass	Under dark glass	Under quartz glass	Under dark glass
	1				
	3			0	
	5	0		3	
	7	1		14	
	10	3		72	
	12	5		100	
	15	8		100	
	20	14			
	25	100			
	30	100	0		0
	40		0		6
	45		15		60
1			38		100
1	30		100		100
2			100		
Controls		0	0	0	0

Irradiation both by the mercury vapor lamp and the sunlight under the dark Corex red purple glass required a considerably longer time to produce killing effects on the larvae as well as on the eggs. This is only to be expected in view of the fact that, while this special glass transmits only ultra-violet, it transmits incompletely in intensity the ultra-violet spectrum. Quartz glass transmits without loss in intensity practically all solar radiation. The literature on biological effects of light indicates, however, that aside from those rays that are actually transformed to heat (controlled here) it is only the ultra-violet that produces lethal effects. This makes it even more evident that ultra-violet, alone, is capable of producing the lethal effects on Heterodera, evident from these tests. From tables 4 and 5 it is possible, by referring across from the first 100 in each column to the time column, to see at a glance the minimum time tested, required for complete killing. The correct time for this is, of course, somewhere between this figure and the next shorter period.

It is true that the sunlight that reaches the surface of the earth is different not only in various localities but also in the same localities on different days and at different times of the day. There are very striking

TABLE 5.—*Effect of different periods of exposure to light on egg viability*

Time of exposure		Percentage killed				
		Exposure to sunlight			Exposure to light from mercury vapor lamp	
Hours	Minutes	Under quartz glass		Under dark glass	Under quartz glass	Under dark glass
		Eggs in masses	Eggs free	Eggs in masses	Eggs in masses	Eggs in masses
	10		25.3			
	20		28.4		77.67	
	30	10.84	30.0		80.0	
1		16.23	33.8		95.0	
1	30	20.6	100.0		95.7	
2		34.7	100.0		96.3	
2	30	47.2			98.0	
3		61.25			99.4	
4		65.0			100.0	
5		100.0			100.0	
6		100.0		95.2		99.3
7				99.8		100.0
8				100.0		100.0
9				100.0		

differences in insolation even on successive days that seem similar in every respect. Freer (7) pointed out that greater intensities of ultra-violet rays may sometimes occur on hazy days than on days that are bright and clear. This finding was corroborated by Lois Godfrey (11) for Hawaii conditions.

To obtain a quantitative estimate of the intensity of ultra-violet, a solution of N/10 oxalic acid and N/100 uranyl sulphate was subjected to the action of the sunlight according to the method of Anderson and Robinson (1) used by Lois Godfrey (11) in Hawaii. The rate of decomposition of the oxalic acid by the solar radiation in the presence of uranyl sulphate is directly proportional to the intensity of the ultra-violet rays. Ten cubic centimeters of the solution were pipetted into a quartz-cover dish and exposed to the sunlight for 30 minutes. A new dish was brought out at every 30-minute period throughout the length of any particular long-time exposure. The solutions after exposure were titrated with N/10 potassium permanganate and the amount of oxalic acid decomposition calculated. The intensity of ultra-violet is indicated by the amount of decomposition produced in the oxalic acid. Table 6 gives the results of tests in which killing effect on nematodes was measured simultaneously with a measurement of intensity of ultra-violet.

TABLE 6.—*Effect of various intensities of ultra-violet radiation as indicated by oxalic acid decomposition on the life of Heterodera larvae*

Time of exposure in minutes	Time of day					
	8: 45–9: 15 a. m.		11: 00–11: 30 a. m.		3: 30–4: 00 p. m.	
	Oxalic acid percentage of decomposition	Percentage killed	Oxalic acid percentage of decomposition	Percentage killed	Oxalic acid percentage of decomposition	Percentage killed
15	64.4	4	71.1	7	51.0	3
20		18		100		11
25		100		100		100
30		100		100		100
	Time of day					
	9: 10–9: 40 a. m.		11: 10–11: 40 a. m.		2: 20–2: 50 p. m.	
15	55.4	4	43.0	3	82.0	47
20		12		8		100
25		100		100		100
30		100		100		100

At the end of 24 hours, all the larvae on the slides, which served as controls, were alive and active. The controls bearing egg masses for all ultra-violet tests, after a period of 24 days, all showed a consistently high percentage of hatching. (Average 98.1 per cent.)

From these observations, it is evident that irradiation with ultra-violet has a lethal effect on both the larvae and eggs of *Heterodera radicicola*. Also, the prolongation of the time of exposure increases the killing effect. The data, furthermore, indicate that the greater the intensity of ultra-violet, the shorter the time required for killing. This latter observation is strikingly shown in table 6. In the exposures on April 23rd, when ultra-violet intensity was high at noon, as manifested by oxalic acid decomposition of 71.1 per cent. in $\frac{1}{2}$ hour, all the larvae were killed in 20 minutes. With the lower intensities of both morning and afternoon, killing was definitely delayed. On April 24th, when, because of cloudiness, the light intensity near noon was cut down (only 43.0 per cent. decomposition), the killing effect was greatly delayed. In the afternoon in bright sunlight, giving 82.0 per cent. decomposition, killing was hastened again.

EFFECT OF COMBINED EXPOSURE TO SUNLIGHT AND DRYING ON THE LIFE OF LARVAE AND ON EGG VIABILITY

Since the investigations have proved that nematodes can be killed by any one of the 3 factors—light, heat (13), and drying, alone—it would ap-

pear that the simultaneous treatment with sunlight and drying would produce lethal effects more rapidly. There is the probability of further reduction of the time by the heat factor.

One hundred fresh, active larvae were placed in a drop of water on each slide and left in a shady place in the laboratory for preliminary drying. As soon as the slide looked dry to the unaided eye it was examined for water under a microscope. If no free water was detected and if the nematodes were all still moving about, the slide was immediately placed on the window sill upon which the sunlight shone directly. The egg masses also were exposed to the sunlight under dry conditions. After the completion of each test they were placed under favorable conditions for hatching to determine the effect on egg viability.

TABLE 7.—*Data showing the combined effect of exposure to sunlight and drying on the life of the larvae and on egg viability*

Time of exposure	Percentage killed		
	Larvae	Eggs in masses	Eggs free
15 sec.	0		
30 "	31		
45 "	60		
1 min.	93	14.0	15.2
2 "	100		27.4
3 "	100	16.1	30.0
5 "	100	17.6	52.4
10 "		23.0	70.4
15 "		69.6	93.8
20 "		98.4	100.0
25 "		99.0	
30 "		100.0	
40 "		100.0	

Larvae were exposed to the sunlight in a dry condition for various periods from 15 seconds to 5 minutes. The eggs were exposed for different periods from 1 minute to 1 hour. Table 7 shows that all the larvae were killed after an exposure of $1\frac{1}{2}$ minutes $\pm$ $\frac{1}{2}$ minute; the eggs in egg masses, after $27\frac{1}{2}$ minutes $\pm$ $2\frac{1}{2}$ minutes; eggs free, $17\frac{1}{2}$ minutes $\pm$ $2\frac{1}{2}$ minutes. The results produced by the sunlight, drying, and heating show a striking combined effect in rapid killing of the nematodes in all stages. Figure 4 shows interesting straight-line relationship between time and killing effect of the sun, depicted on a semilog graph. The relative rates of killing on exposure to the sun are clearly shown here.

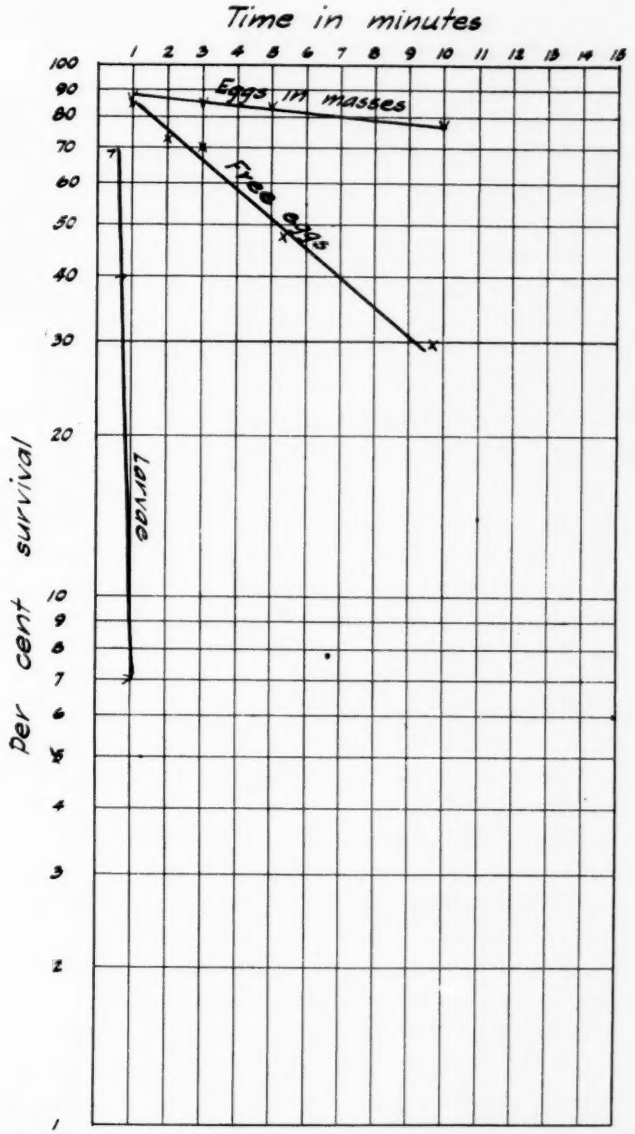

FIG. 4. Semilog graph showing percentage survival of *Heterodera radicicola* larvae and eggs, at different intervals, when exposed to the direct action of sunlight, sun heat, and sun drying. The outstanding feature of this graph is the high resistance of eggs protected in their gelatinous matrix, as compared with the free eggs and larvae. The free eggs are, likewise, considerably more resistant than the larvae.

At the end of 24 hours control slides showed all the larvae to be alive. Egg masses placed as checks, according to the usual procedure, gave hatching of 97.3 and 98.7 per cent.

Another test was made with egg masses covered with a very thin layer of soil (about $1\frac{1}{2}$ mm.) to get some indication, if possible, as to the extent to which the killing effect of ultra-violet penetrated through such a medium. In one set, moist conditions were maintained, the soil being kept moist and exposure to midday sun being in a Petri dish covered with quartz glass. There were 3 replications of treatments. In this case, average percentages of survival were as follows: 30 minutes' exposure, 96.4; 1 hour, 91.3; 2 hours, 84.8; 4 hours, 7.3; 6 hours, 0.9; 7 hours, 0. Complete killing in this case, in $6\frac{1}{2}$ hours $\pm \frac{1}{2}$ hour, is to be compared with $4\frac{1}{2}$ hours $\pm \frac{1}{2}$ hour, where egg masses were exposed directly, under similar conditions (ignoring the possibility of great differences in sunlight intensity on the 2 days). In another set, the eggs were covered with air-dry soil and exposed directly to the midday sun. Here, of course, drying is a factor, in addition to ultra-violet. Here complete killing was attained in $1\frac{1}{4}$ hours $\pm \frac{1}{4}$ hour, which is to be compared with $27\frac{1}{2}$ minutes $\pm 2\frac{1}{2}$ minutes in the case of direct exposure of egg masses, without soil, on another day. Certainly in both tests marked insulation on the part of the soil against lethal effects of sunlight is manifested.

EFFECT OF EXPOSURE OF ROOT GALLS TO DIFFERENT PERCENTAGES OF RELATIVE HUMIDITY AND TO SUN DRYING

Preliminary observations and experience having shown that *Heterodera radicicola* as contained within more or less woody roots of plants is protected against unfavorable environmental conditions, a final test was made to determine approximately the extent to which such protection acts. For this purpose typical nematode root galls were selected from cowpea plants and from pineapple plants. The cowpea galls were on relatively young roots and consequently were more or less soft and succulent. Some of the contained egg masses were external, as illustrated in the senior writer's paper (9) on technique. The pineapple galls were mostly terminal and therefore more or less succulent at the very tip but were much more woody, in general, than the cowpea galls, and the egg masses were entirely internal.

Such galls were washed and dried on paper towels and left for a few minutes to become thoroughly dry on the surface. They were then exposed, as described for larvae and eggs, by means of desiccators, to 50, 60, 70, 80, and 90 per cent relative humidity, to complete dryness (over concentrated sulphuric acid), and to direct sunlight, all for varying periods. Immediately after the completion of each test the roots were dissected to re-

TABLE 8.—*Percentage survival of Heterodera radicicola in root galls of cowpea (c) and pineapple (p) exposed to different relative humidities*

Time of exposure, days	1		2		3		4		5		6	
Relative humidity (per cent)	c	p	c	p	c	p	c	p	c	p	c	p
50	86.2	91.0	0	18.0	0	0	0	0				
60	97.3	98.5	95.6	94.7	94.9	95.9	24.9	32.8	0	0	0	0
70	97.5	98.7	97.5	97.4	96.9	97.0	26.6	49.2		8.0	0	0
80	98.8	98.1	98.7	98.9	97.8	97.1			75.7	73.5		
90	99.1	99.2	98.9	99.2	99.1	99.2						
100												
0	0	52.2	0	0	0	0						
Sunlight	8 hr.		16 hr.		24 hr.		30 hr.					
	0	52.1	0	2.0	0	0						

Time of exposure, days	7		8		9		10		15		20	
Relative humidity (per cent)	c	p	c	p	c	p	c	p	c	p	c	p
50												
60												
70	0	0										
80	33.8	39.5	0	0								
90	96.8	97.3	74.8	84.1			74.3	79.8	49.9	69.0	49.2	69.7
100							82.6	89.3	74.8	83.4	69.2	74.3
0												

move contained egg masses, which were mounted on slides in the usual method for incubation at room temperature.

The series of tests was repeated 3 times, with 1 root of each kind in each test. Results were surprisingly uniform, considering the great variability of protecting root material surrounding the eggs. Results in averages of the 3 tests, only, are given here, in tabulated form, in table 8. Control roots, in which the egg masses were dissected out of fresh roots and incubated directly without exposure, gave a uniformly high rate of viability of eggs, over 99 per cent. in both cowpea and pineapple roots.

It is possible to see at a glance the important conclusions that are to be drawn from this test. The viability of eggs is maintained for a much longer period when they are protected by the root than when free. At 50 per cent relative humidity, for example, eggs in roots survive for over a day in the case of cowpea and over 2 days in woody pineapple roots, as compared with only about 2 hours in freed egg masses and only 1 hour as free eggs. With higher humidities, life is maintained for a longer period. At 80 per cent humidity, all were killed by the 8th day, while at 90 and 100 per cent there was still a high proportion of living eggs at the end of the 20th day. There was a gradual decrease in numbers of living eggs, and one is justified in assuming that drying would eventually become complete at 90 per cent humidity, with consequent death of the eggs. In our tests, after prolonged exposure at the higher humidities, the roots became moldy and gradually decomposed, thus introducing an external uncontrolled factor.

With complete drying and with exposure to direct sunlight, killing was, likewise, much slower in the root galls than with free eggs and egg masses. Killing was complete, however, in less than 24 hours in both cases, somewhat faster in the cowpea than in the pineapple galls. Sunlight exposure killed the nematodes in the cowpea roots in less than 8 hours. The well-known fact of low penetrating power of ultra-violet should be noted here in explanation of the much-slower killing of eggs in roots than of eggs exposed directly.

SUMMARY AND CONCLUSIONS

As a first step in the study of environmental relations of the root-knot nematode, *Heterodera radicicola*, a large number of egg masses were placed under favorable conditions for hatching, in drops of fresh tap water on slides in moist chambers, at room temperature (24 to 28° C.). The average hatch from 84 egg masses was 97.8 per cent. The average number of eggs per egg mass was 416.

In the study of effects of different percentages of relative humidity (as obtained over sulphuric acid of controlled densities, in desiccators) on

longevity of larvae and eggs, the following results were obtained: at 50 per cent humidity, larvae survived for 3½ minutes ± ½ minute; eggs in masses for 2¼ hour ± 15 min; free eggs for 1¼ hours ±15 minutes; eggs as protected by root-gall tissues for 1½ days ± ½ day. At 90 per cent humidity, larvae survived for 25 minutes ± 5 minutes; eggs in egg masses for 8½ hours ± ½ hour; free eggs for 5½ hours ± ½ hour; eggs in root-gall tissues, 75 per cent still alive after 20 days' exposure. For intermediate humidities, periods of survival were intermediate. One hundred per cent humidity kept all stages alive throughout the course of the experiment (or until molds and putrefaction killed them). Complete dryness brought about killing as follows: larvae, in 2½ minutes ± ½ minute; eggs in egg masses in 1¾ hours ± ¼ hour; free eggs in 52½ minutes ± 7½ minutes; eggs in root-gall tissues in 1½ days ± ½ day.

Ultra-violet radiation was, likewise, found to have a relatively quick lethal effect on this nematode in different stages. The ultra-violet of the midday sun on a clear day in April in Hawaii, passing through quartz glass covers, killed the different stages in drops of water at nonlethal temperatures as follows: larvae in 22½ minutes ± 2½ minutes; eggs in egg masses in 4½ hours ± ½ hour; free eggs in 1¼ hours ± ¼ hour. Killing with the ultra-violet of a Cooper-Hewitt air-cooled quartz mercury vapor lamp at a distance of 50 cm. was always in a shorter period than in sunlight. Measurement of the ultra-violet made at the time of some of the tests showed killing was hastened with increased intensity of ultra-violet.

Killing of the nematodes from the combined effects of sunlight, heat, and drying took place in a remarkably short time. Larvae were killed in 1½ minutes ± ½ minute; eggs in egg masses in 27½ minutes ± 2½ minutes; free eggs in 17½ minutes ± 2½ minutes; eggs in root-gall tissues of cowpea in less than 8 hours and in the more woody tissues of pineapple roots in about 16 hours (8-hour periods on 2 successive days).

Analysis of percentage survival of larvae and free eggs for different periods shorter than the lethal period, for many of the different kinds of treatments, showed an interesting straight-line relationship between time and percentage survival, as graphed on semilog paper.

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PHYSALOSPORA ZEICOLA ON CORN AND ITS TAXONOMIC AND HOST RELATIONSHIPS

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INTRODUCTION

In an earlier paper the senior writer (1) reported that *Diplodia frumenti* E. and E., *D. natalensis* Evans, *D. gossypina* Cke., and *D. tubericola* E. and E. cause similar ear rots of corn in Florida. Since the morphological characters of the imperfect stages of these 4 organisms also are similar, the only means left to determine whether they are the same or different species is to compare their perfect stages. Stevens (8) has shown that *D. natalensis* and *D. gossypina* are synonymous, as they have *Physalospora rhodina* (Berk. and Curt.) Cooke as their perfect stage; but no one has yet reported the perfect form of either *D. frumenti* or *D. tubericola*.

In 1929 a species of Physalospora was found on cornstalks in Florida and studies were undertaken to determine its pathogenicity and identity and to determine whether it is the perfect stage of *Diplodia frumenti*. In the course of these studies, information was obtained on the comparative susceptibility of ears of corn in different stages of development to the fungus. Also, a number of different plant species were inoculated with this Physalospora, *P. rhodina*, and *D. tubericola* to obtain some information as to their comparative host range. Results of these investigations are given in this paper.

CAUSAL ORGANISM

The first specimens of the species of Physalospora herein considered were collected in the spring of 1929 on old dead cornstalks in fields in the vicinity of Melrose and Gainesville, Florida. Since that time mature asci and ascospores were usually found in late summer and fall on the nodes and internodes of the culm near the base of the plant after the infected stalks had dried.

Five ascospore cultures of this Physalospora were grown on various kinds of media. Two of these produced pycnidia in potato-dextrose agar and sterilized corn meal, which contained pycnospores typical of those produced by *Diplodia frumenti*. The same 2 cultures also formed pycnidia on the inoculated stems of geranium plants that were growing in the greenhouse. The other 3 cultures failed to fruit on media and geranium stems. Cultures obtained from either ascospores or pycnospores of this Physalospora and from pycnospores of the species of Diplodia fruited more readily

on artificial media immediately after they were isolated than after they had been carried in culture for several months. Old cultures, however, were pathogenic, produced spores on the host plant, and when reisolated sporulated in culture.

Pathogenicity. In July, 1931, green cornstalks that had ceased to elongate were inoculated with 5 cultures of this Physalospora by placing the mycelium in an incision made by a downward stroke with a scalpel above the 4th or 5th node and wrapping the wound with nurseryman's tape. Notes on infection (Table 1) were taken 6 weeks later. The pith and epidermis of the infected stalks were blackened in the zone invaded by the fungus for several inches on either side of the point of inoculation. Three of the cultures formed the perfect stage on some stalks and the imperfect on others, while 2 produced the imperfect stage only. On some diseased stalks no fruiting bodies were formed, but stromata of the fungus were present on the surface in the infected zone. The perithecia, asci, and ascospores were similar morphologically to those of the Physalospora from which the cultures used in the inoculations were obtained, and the pycnidia and pycnospores were like those of *Diplodia frumenti*, which is common on corn in Florida.

TABLE 1.—*Results obtained by inoculating cornstalks with mycelium from ascospore cultures of the Physalospora from corn*

Culture	Number of stalks				
	Inoculated	Infected	With perithecia alone	With pycnidia alone	With stromata containing no spores
1	27	27	19	2	6
2	25	25	0	25	0
3	25	25	0	25	0
4	25	25	13	4	8
5	25	23	8	13	2
Check	25	2	0	2	0

Ears of corn in the early-milk stage were inoculated by inserting mycelium from pure cultures of the Physalospora into wounds made in the shanks, and the results are given in table 2. Many of the ears were invaded and thoroughly rotted and blackened by the fungus, while in others the infection was scattered over the ear (Fig. 1, A). The rot produced by this organism was similar to that caused by *Diplodia frumenti* (1). The fungus produced perithecia on the husks of some ears and pycnidia on others.

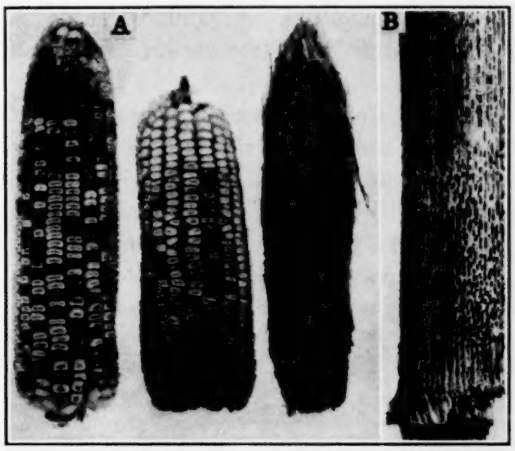

FIG. 1. A. Ears of corn showing kind of rot produced by artificial inoculation, with mycelium developing from an ascospore of *Physalospora zeicola*. B. Perithecia of *P. zeicola* breaking through the epidermis of a cornstalk.

TABLE 2.—*Results obtained by inserting mycelium of ascospore cultures of the Physalospora from corn into the shanks of ears in the early-milk stage of development*

Culture	Number of ears	
	Inoculated	Infected
1	22	12
2	25	10
3	23	18
4	24	19
5	23	10
Check	24	1

Taxonomy. In 1890 Ellis and Everhart (3) described a species of Physalospora on cornstalks and named it *Physalospora zeicola* E. and E., the original description of which is as follows:

"*Physalospora zeicola* E. and E. On dead stalks of Zea mays exposed to the weather through the winter, Newfield, N. J. Apr. 1890. Perithecia gregarious, minute ($\frac{1}{4}$–$\frac{1}{3}$ mm) covered by the cuticle which is slightly raised and pierced by the obtusely conical, black and shining ostiolum. Asci clavate-cylindrical, 75–80 × 12–15 μ, nearly sessile, with abundant paraphyses, sporidia crowded-biserate, elliptical or almond shaped, hyaline, granular, 18–20 × 8–10 μ."

The perithecia of the Physalospora on cornstalks in Florida are similar to those of *Physalospora zeicola* in that they are black, gregarious, and break

through longitudinal cracks in the epidermis (Fig. 1, B). The Florida fungus also forms its perithecia in stromata on the surface of the culm at the nodes.

The asci of the Florida Physalospora have the same shape but are longer than those of *P. zeicola,* the measurements of the former being 95–140 × 10–13 μ. Also, certain characteristics of the asci that were not mentioned in Ellis and Everhart's (3) description of *P. zeicola* were observed in the Florida Physalospora. The young ascus has its granular contents enclosed in a sac that lies in the space enclosed by the outer wall of this structure (Fig. 2, C). After the spores are formed and mature the wall of the sac

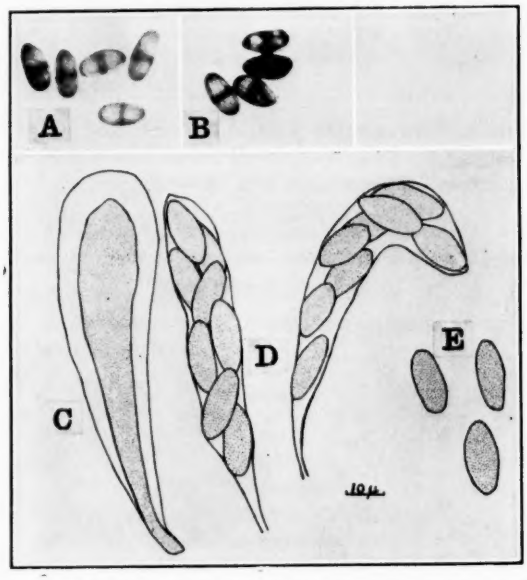

FIG. 2. A and B. Photomicrographs of pycnospores from: A, *Diplodia frumenti;* B, *Physalospora zeicola.* C–E. Drawings of asci and ascospores of *P. zeicola:* C, young ascus; D, mature asci; E, mature ascospores.

remains to enclose the spores, while the outer wall disappears (Fig. 2, D). When cut across the asci have a white appearance that, according to Stevens (8), is characteristic of the genus Physalospora.

Ascospores of the Florida Physalospora (Fig. 2, E) are of the same shape and are unicellular, hyaline, and granular, like those of *P. zeicola.* Two hundred ascospores of the former measured 13–27 × 6–11 μ, mostly 20–23 × 8–9 μ, thus agreeing very closely in size with those of *P. zeicola.*

Physalospora zeicola differs from *P. rhodina* in that it has shorter and narrower ascospores, as those of the former measure 13–27 × 6–11 μ, mostly 20–23 × 8–9 μ, while those of the latter, according to Stevens (8), measure

24–42 × 7–17 μ, mostly 30–35 × 11–14 μ. Stout (9) reported that asci of *P. zeae* Stout measure 85–150 × 13–22 μ and the ascospores 19–25 × 6.5–8 μ and concluded that it was a species distinguished from *P. zeicola* because of its larger asci and longer but narrower spores. It thus appears that the morphological characters of the Florida Physalospora are, in general, very similar to those given for *P. zeicola*, as indicated in the above comparisons, and it is referred to that species.

On potato-dextrose agar an ascospore culture of *Physalospora zeicola* cannot be distinguished from a pycnospore culture of *Diplodia frumenti*. The young mycelium of each is hyaline, granular, septate and branched, producing a loose, flocculent, white aerial growth. When the cultures grow older, the mycelia become brown and stromatic masses and pycnidia are formed on the surface of the media. On severely diseased ears cultures from each source form brown, felty masses of hyphae on the kernels and husks.

The imperfect as well as the perfect stage of *Physalospora zeicola* developed on cornstalks artificially inoculated with mycelial cultures derived from ascospores of this fungus. The morphological characters of the pycnidia and pycnospores observed on these infected stalks were similar to those occurring on stalks naturally and artificially inoculated with *Diplodia frumenti*. Pycnospores of *P. zeicola* from artificially inoculated stalks measured 21–29 × 10–14 μ, mostly 25–27 × 12–13 μ, and from culture 21–33 × 12–15 μ, mostly 26–28 × 13–14 μ; and those of *D. frumenti* from naturally infected stalks measured 19–31 × 11–15 μ, mostly 25–27 × 13–14 μ, and from culture 20–28 × 11–15 μ, mostly 24–26 × 13–14 μ (Tables 3 and 4).

TABLE 3.—*Classification of pycnospores developing from the perfect and imperfect stages of Physalospora zeicola according to length*

Source of culture	Total number spores	Number of spores having a given length in microns													
		19	20	21	22	23	24	25	26	27	28	29	30	31	33
Physalospora zeicola from cornstalks	100			2	2	5	9	26	22	25	6	3			
Physalospora zeicola from culture	100			2	1	11	3	14	23	15	15	11	6		1
Diplodia frumenti from cornstalks	100	1	5	7	15	20	18	44	24	28	19	13	4	2	
Diplodia frumenti from culture	100		1	5	8	14	24	21	18	4	5				

TABLE 4.—*Classification of pycnospores developing from the perfect and imperfect stages of Physalospora zeicola according to width*

Source of culture	Total number spores	Number of spores having a given width in microns					
		10	11	12	13	14	15
Physalospora zeicola from cornstalks	100	3	15	38	28	16	
Physalospora zeicola from culture	100			9	33	39	19
Diplodia frumenti from cornstalks	100		10	28	82	61	19
Diplodia frumenti from culture	100		3	7	55	29	6

Thus, the imperfect spores from the 2 sources agree closely in size.

A small portion of a specimen of *Diplodia frumenti* on a cornstalk collected by Langlois in Louisiana in 1886 was obtained from the U. S. Herbarium, Washington, D. C. Twenty-six pycnospores found on this material measured 17–26 × 10–15 μ, thus agreeing very well in size with pycnospores of *Physalospora zeicola* and *D. frumenti*, reported above, but are somewhat larger than the measurements reported by Ellis and Everhart (2) in their original description of *D. frumenti* in which the dimensions were given as 15–18 × 12 μ.

Since the imperfect stage of *Physalospora zeicola* cannot be distinguished from *Diplodia frumenti* in its growth on media in pure culture and on cornstalks and ears and since both form pycnidia in the same manner, containing pycnospores of similar shape, color, septation, and approximately the same dimensions, *P. zeicola* is considered to be the perfect stage of *D. frumenti*. Photomicrographs of pycnospores of *D. frumenti* and *P. zeicola* are shown in figure 2, A and B.

COMPARATIVE SUSCEPTIBILITY OF EARS OF CORN AT DIFFERENT STAGES OF GROWTH

Experiments were conducted in the field in which ears of corn of different stages of growth were inoculated by different methods. The inoculum consisted of pycnospores and mycelium from pycnospore cultures of *Physalospora zeicola*. At intervals of 5 to 9 days from June 10 to July 9, inclusive, 17 to 35 ears were inoculated by each of 4 methods, as follows: (1) Approximately 10 cc. of a spore suspension sprayed on ear tips; (2) approximately 10 cc. of a spore suspension sprayed in the crevice between the ear and sheath; (3) approximately 10 cc. of a spore suspension injected

into the husks near the butt end with a hypodermic syringe; (4) a corn kernel on which the fungus was growing was inserted in the shank of each ear between the butt end of the ear and its point of attachment to the stalk.

The inoculated ears were harvested August 18 and examined for visible signs of infection, as indicated by the blackened condition of diseased kernels. As shown in table 5, infection was obtained by all 4 methods of in-

TABLE 5.—*Comparative susceptibility to Physalospora zeicola of corn ears in different stages of development*

Date of inoculation	Method of inoculation	Stage of development of ears	Total ears inoculated	Ears with rotted kernels	Ears with pycnidia on husks
June 10	Spore suspension sprayed on ear tips	Blister	23	3	8
" 17	"	Early milk	22	3	15
" 22	"	Milk	23	2	7
" 30	"	Late milk	25	1	3
July 9	"	Dent	25	0	0
June 10	Spore suspension sprayed in crevices between ear and sheath	Blister	25	3	14
" 17	"	Early milk	23	3	14
" 22	"	Milk	17	0	4
" 30	"	Late milk	24	2	2
July 9	"	Dent	25	0	1
June 10	Spore suspension injected into husks near the butt	Blister	25	9	21
" 17	"	Early milk	25	4	16
" 22	"	Milk	lost	.....	.....
" 30	"	Late milk	25	5	6
July 9	"	Dent	26	0	5
June 10	Inoculum inserted in ear shank	Blister	35	9	33
" 17	"	Early milk	17	7	14
" 22	"	Milk	27	15	21
" 30	"	Late milk	24	5	13
July 9	"	Dent	25	2	0

oculation. The method producing the highest percentage of infected ears with visible signs of rotting was that in which an infected corn kernel was inserted in the shank. Injecting a spore suspension into the husks gave a higher rate of infection than was obtained by spraying the inoculum on the tips of the ears and in the crevices between the ears and sheaths. The fact that inoculations made by wounding the ears gave higher rates of infection than those made without wounding was probably due to the possibility that the spores injected into the ear husks and the mycelium inserted in the moist shanks suffered less from lack of moisture than the spores sprayed on the tips and butts of the ears.

Ears in the early stages of growth were more susceptible to infection than those in the later stages of development. This was probably because the young, tender ears were easily penetrated and contained more moisture to support the growth of the fungus than older ears that were beginning to dent and harden. The fungus produced pycnidia on the husks of some ears that showed no kernel infection as well as on those whose kernels showed signs of rotting.

Under natural conditions more ears are infected by *Physalospora zeicola* at the butt than at the tip. Such is also true of ears naturally infected with *Diplodia zeae* (Schw.) Lev., according to Raleigh (6). Ears inoculated at the tip with a pycnospore suspension of *P. zeicola* had the inoculum forced on them in a stream from a pressure sprayer, thus placing the spores well down between the silks and in the crevices between the tips of the husks where moisture conditions were suitable for germination and fungus growth. Under natural conditions spores falling on the tips of ears seldom meet with conditions suitable for germination (6).

HOSTS OF PHYSALOSPORA ZEICOLA, PHYSALOSPORA RHODINA AND DIPLODIA TUBERICOLA

Taubenhaus (10) reported that *Diplodia natalensis* and *D. gossypina,* which, according to Stevens (8), are synonymous names for the imperfect stage of *Physalospora rhodina,* caused the typical Java black rot of sweet potatoes. Meier (5) found that *D. tubericola* from sweet potato would cause the stem-end root of watermelon; and Fawcett and Burger (4) discovered that Diplodia isolated from gumming peach trees caused a gumming of orange trees and Diplodia isolated from orange trees caused a gumming of peach trees. Cross-inoculation studies made by Eddins (1) showed that *D. tubericola, D. natalensis,* and *D. gossypina* caused a rot of ears of corn similar to that caused by *D. frumenti,* the imperfect form of *P. zeicola,* and each caused a similar rot of oranges, grapefruit, sweet potatoes, cotton bolls, and watermelons. In order to get some idea as to the extent of the host range of *P. zeicola, P. rhodina,* and *Diplodia tubericola,* 31 species of woody and herbaceous plants representing 24 families were inoculated with mycelium from pure cultures originating from pycnospores of the imperfect stages of the 3 organisms.

From 5 to 10 inoculations were made in the branches, stems, and other parts of the different plants. A branch or stem inoculation was made by inserting mycelium of the fungus scraped off the surface of potato-dextrose agar into a small wound made in the bark or outer layer of tissues with a sharp knife. After inoculation the wound was first covered with waxed paper and then wrapped with nurseryman's tape. Branch or stem inoculations were made in all plants of the different species except *Citrullus vulgaris* Schrad. (watermelon) and *Gossypium hirsutum* L. (cotton), in which

the fruits alone were inoculated, and *Ipomoea batatas* (L.) Lam. (sweet potato), in which the fleshy roots were inoculated. A watermelon was inoculated by sponging it off at the stem end with 50 per cent alcohol, and placing mycelium of the fungus in the bottom of a small plug cut into the stem, after which the plug was replaced and the wound was covered with waxed paper and nurseryman's tape. Green cotton bolls and sweet potatoes were inoculated in the same manner as watermelons except that their entire surfaces were sterilized before inoculation and inoculum was inserted in wounds at any convenient point on the surfaces of the bolls and roots.

The inoculation experiments were carefully checked by wounding branches, stems, and other parts of the different plants and treating them similarly to those that were inoculated except that inoculum of the different fungi was not introduced into the wounds.

The inoculations were made in the summer of 1930 and 1931 and the criterion for infection was the production of pycnidia and mature pycnospores in the region killed by the Physalospora or Diplodia in inoculated areas on the plants. From 1 to 6 weeks was required for these organisms to produce pycnidia on their hosts. A longer time was required for the

TABLE 6.—*Host plants of Physalospora zeicola, P. rhodina, and Diplodia tubericola as determined by the production of pycnidia and pycnospores following artificial inoculation*

Family	Species	Family	Species
Aceraceae	*Acer floridanum* Thumb.	Magnoliaceae	*Magnolia grandiflora* L.
Amygdalaceae	*Amygdalus persica* L.	Malaceae	*Pyrus communis* L.
	Prunus angustifolia Marsh.	Malvaceae	*Gossypium hirsutum* L.
		Meliaceae	*Melia azedarach* L.
Artocarpaceae	*Ficus carica* L.	Mimosaceae	*Acacia macrantha* Thumb.
Convolvulaceae	*Ipomoea batatas* (L.) Lam.	Papayaceae	*Carica papaya* L.
Cucurbitaceae		Pinaceae	*Pinus caribaea* Morelet
Ebenaceae	*Citrullus vulgaris* Schrad.	Poaceae	*Zea mays* L.
Euphorbiaceae	*Diospyros virginiana* L.	Proteaceae	*Grevillea robusta* A. Cunn.
	Aleurites fordii Hemsl.	Rutaceae	*Citrus maxima* (Burm.) Merrill
	Euphorbia pulcherrima Willd.		*Citrus nobilis* Lour. var. *unshiu* Swingle
	Ricinus communis L.		*Citrus sinensis* Osbeck
Fabaceae	*Crotalaria striata* DC.	Spondiaceae	*Mangifera indica* L.
Fagaceae	*Quercus laurifolia* Michx.		
Geraniaceae	*Pelargonium hortorum* Bailey		
Hamamelidaceae	*Liquidambar styraciflua* L.		
Juglandaceae	*Hicoria glabra* (Mill.) Britt.		
Lauraceae	*Camphora camphora* (L.) Karst.		
	Persea persea (L.) Cockerell		
	Sassafras sassafras (L.) Karst.		

fungus to fruit on the woody plants than on the herbaceous ones. They usually fruited within a week to 10 days on watermelons, while on cotton bolls 2 to 3 weeks were needed and on sweet potatoes a month to 6 weeks were required. No difference was observed in symptoms produced on the different hosts by the 2 species of Physalospora and *D. tubericola*. None of the check inoculations in the different plants showed any infection from Diplodia. A list of the host plants, as determined by these inoculation experiments, is given in table 6.

SUMMARY

A Physalospora found on cornstalks in Florida has been identified as *Physalospora zeicola* E. and E., and it has been demonstrated that it produces an ear rot similar to that caused by *Diplodia frumenti*.

Data are presented to show that *P. zeicola* is the perfect stage of *D. frumenti*, and the fungus is referred to in this paper by its perfect-stage name. Since Stevens (8) has shown that *P. rhodina* is the perfect stage of *D. natalensis* and *D. gossypina*, it would be less confusing to refer to the fungus by its perfect-stage name than to call it *D. natalensis* when it appears on citrus and *D. gossypina* when found on cotton.

Ears of corn in the early stages of growth proved more susceptible to infection with *P. zeicola* than ears in the later stages of development.

Physalospora zeicola, *P. rhodina*, and *Diplodia tubericola* grew and produced pycnidia on 31 host plants inoculated with mycelium from pure cultures obtained from pycnospores of the imperfect stages of the 3 organisms.

These studies indicate a need for reclassification of the species of Diplodia listed in Saccardo (7), since it may be found that many others having similar morphological characters will have the same host range.

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DECAY OF WOOD AND GROWTH OF SOME HYMENOMYCETES AS AFFECTED BY TEMPERATURE[1]

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Investigations pertaining to the effect of temperature on the development of wood-destroying fungi have been limited largely to determining the cardinal points for spore germination and for mycelial growth on culture media and to studying the effect of heat in arresting their development in wood. So far as known, there have been no attempts to determine by means of laboratory experiments the relation of temperature to the rate of wood decay. The opportunity to study the relation of temperature to decay of wood and mycelial growth on culture media was supplied in the course of investigations of the effect of some fungi on the mechanical properties of wood. Although the work attempted was not comprehensive, the results may be of interest and are recorded briefly in this paper.

MATERIALS AND METHODS

The fungi used were *Lenzites sepiaria* Fries, *Polystictus versicolor* (L.) Fries, and *Lentinus tigrinus* Fries. The original cultures, with the exception of *L. tigrinus*, were obtained from the Bureau of Forest Pathology, Forest Products Laboratory, Madison, Wisconsin. *Lenzites sepiaria* and *P. versicolor* are wood-destroying fungi of great commercial importance on forest products, the former occurring on softwood and the latter on hardwood timber, principally. *Lentinus tigrinus* is typically a hardwood-rotting organism but is of little economic significance.

Ninety-millimeter Petri dishes, containing 10 cc. of malt-extract agar, were used in studying the effect of temperature on mycelial growth on culture media. The medium was prepared as follows: Trommers malt extract (plain), 25 gm.; agar agar (Bacto granulated), 20 gm.; distilled water, 1,000 cc. Uniform squares of mycelium taken from the growing edge of a plate culture of each fungus were placed in the center of the Petri dishes. These plates were distributed immediately to 13 incubators, which ranged in temperature from 0 to 50° C. Three different series were used, each one consisting of 5 plates for each organism at each temperature. Two diameter measurements in millimeters were taken of each mycelial disk at 24-hour intervals for a period of 8 days. The average of the 2 measurements was used to represent the growth of the culture at the time of measurement.

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The average growth in diameter at the end of any given period was based on the average of the 15 measurements taken for each organism at each temperature.

In studying the effect of temperature on the rate of wood decay, blocks of *Pinus resinosa* Solander, *Picea glauca* (Moench) Voss, *Betula papyrifera* Marshall, and *Populus tremuloides* Michaux were rotted under controlled temperature conditions. The blocks, 112 in number, and $1 \times 1 \times 3$ in., were oven-dried at 100° C. to a constant weight, weighed, and soaked in water until a moisture content of approximately 100 per cent, oven-dry basis, was reached. They were then autoclaved for 30 minutes at 15-pounds pressure and a block of each species of wood was transferred to 2-qt. fruit jars in which pure cultures of *Lenzites sepiaria, Polystictus versicolor,* and *Lentinus tigrinus* had become established on agar. The culture jars, 28 in number, were placed immediately in incubators maintained at constant temperatures of 22, 27, 32, and 35° C. After an incubation period of 2

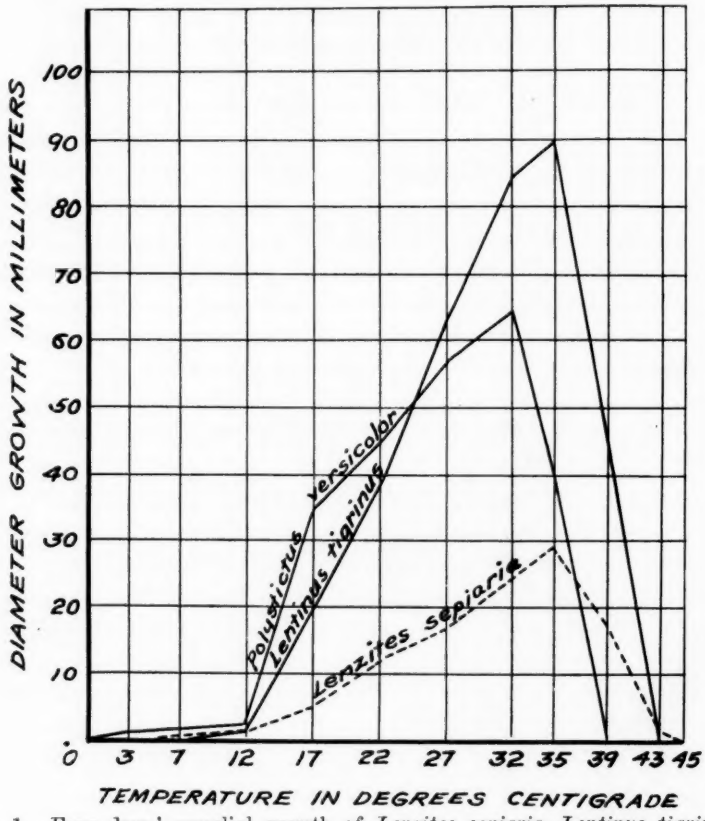

FIG. 1. Four days' mycelial growth of *Lenzites sepiaria, Lentinus tigrinus,* and *Polystictus versicolor* on malt-extract agar under different temperature conditions.

months, the decaying blocks were removed from the jars and their oven-dry weights again recorded. The relative losses in weight induced by decay at the different temperatures were determined from the original and final oven-dry weights.

RESULTS

Mycelial Growth on Culture Media

The mean growth in diameter in millimeters of the several fungi after various periods of exposure and for 4 days' growth at different temperatures is shown in table 1 and figure 1, respectively. It is noted that the mean

TABLE 1.—*The mean diameter growth on malt-extract agar of Lenzites sepiaria, Lentinus tigrinus, and Polystictus versicolor after various periods of exposure at different temperatures*

Organism	Days	Average diameter growth in millimeters at various temperatures in °C.												
		50	45	43	39	35	32	27	22	17	12	7	3	0
Lenzites sepiaria	1	0	0	0	+[a]	3	2	+	+	+	0	0	0	0
	2	0	0	0	2	10	7	2	+	+	0	0	0	0
	3	0	0	+	7	21	17	12	7	3	0	0	0	0
	4	0	0	+	17	29	25	17	12	5	+	0	0	0
	5	0	+	1	23	40	38	25	19	12	+	+	0	0
	6	0	+	2	28	55	52	38	27	17	1	+	0	0
	7	0	+	3	35	65	61	47	33	22	3	+	0	0
	8	0	+	4	44	77	73	57	40	28	8	2	0	0
	15	0	+	14	–	–	–	–	–	70	21	10	0	0
Lentinus tigrinus	1	0	0	0	+	12	10	7	2	+	0	0	0	0
	2	0	0	0	7	39	34	20	9	2	+	0	0	0
	3	0	0	0	25	75	65	41	21	7	+	0	0	0
	4	0	0	0	44	90	85	63	38	19	+	+	0	0
	5	0	0	0	58	–	–	80	54	26	2	+	0	0
	6	0	0	0	73	–	–	–	68	35	7	+	0	0
	7	0	0	0	90	–	–	–	80	46	10	+	0	0
	8	0	0	0	–	–	–	–	90	55	12	+	0	0
	15	0	0	0	–	–	–	–	–	–	40	2	0	0
Polystictus versicolor	1	0	0	0	0	9	12	11	7	2	0	0	0	0
	2	0	0	0	+	18	28	25	18	9	+	0	0	0
	3	0	0	0	+	32	47	42	32	19	+	+	+	0
	4	0	0	0	+	40	65	57	45	35	2	1	+	+
	5	0	0	0	+	50	83	73	56	47	7	2	1	+
	6	0	0	0	1	56	90+	90	69	59	11	3	2	+
	7	0	0	0	2	62	–	–	81	70	15	5	3	1
	8	0	0	0	2	70	–	–	90	79	19	8	5	2

[a] + indicates trace of growth.

increment at any given period of exposure increases progressively as the optimum temperature, based on the greatest mean diameter growth, is approached. The mean growth rate for the individual successive 24 hour-periods is not always the same. Although the mean diameter growth for the entire period is consistently greater at the optimum than at any other temperature, increments for given 24-hour exposure periods are sometimes greatest at temperatures other than the optimum ones. Growth rate is found to vary to some extent with time of exposure, but there is no definite progressive decrease in daily increment at higher temperatures nor progressive increase of daily increment at lower temperatures, as has been reported by some investigators.

Of the 3 fungi, *Lenzites sepiaria* showed the slowest rate of growth, 9 days being required to cover a 90-millimeter Petri dish at the optimum temperature. *Lentinus tigrinus* and *Polystictus versicolor* covered the same area in approximately 4 days and 5½ days, respectively. The cardinal temperatures for growth of *Lenzites sepiaria* were found to be as follows: optimum 32–35° C.; minimum, approximately 5° C.; and maximum, 45° C. These results vary slightly from those obtained by Snell (5) but agree rather closely with those reported by Falck (2, pp. 9–32) for this same fungus. Snell found the optimum to be between 30 and 34° C.; the minimum, approximately 8° C.; and the maximum, 40 to 44° C.; while Falck reported 35° C. as the optimum, 5° C. as the minimum, and 44° C. as the maximum point. Humphrey (4) states that the optimum for development rests between 28 and 32° C. The use of different strains of this organism could easily account for such variations in the temperature relations.

Lentinus tigrinus grew more rapidly but had a narrower range of growth than either of the other fungi. It had the same comparatively high optimum temperature for growth, 32 to 35° C., as *Lenzites sepiaria*, but its extreme limits were not so widely divergent, the minimum being approximately 7° C. and the maximum 40 to 43° C. An increase of a few degrees above the optimum temperature retarded growth to a much greater extent than a corresponding decrease below it. This is strikingly evident from a comparison of the growth figures at 22, 32, and 43° C. At the end of 4 days, growth at 22° C. was almost ½ that at 32° C., while, at 43° C., growth had been inhibited.

The cardinal temperatures of *Polystictus versicolor* were the lowest of all, its optimum point being between 27 and 32° C., the minimum at approximately 0° C., and the maximum about 40° C. The retardation of growth resulting from a slight increase in temperature above the optimum was decidedly pronounced. It is noted from table 1 that an increase of 9° above was practically equivalent to a decrease of 23° below the optimum in

its retarding influence on growth. An increase of less than 10° C. inhibited growth, while a decrease of 30° C. was needed to accomplish the same result.

Decay of Wood Induced at Different Temperatures

The decay of wood induced by the 3 organisms under different temperature conditions, as determined from the relative losses in weight of wood, is shown in table 2 and figure 2. For the purposes of this discussion, the

TABLE 2.—*The average percentage loss in weight of wood rotted under different temperatures for a 3-month period*

Organism	Temperature in °C.	Average percentage loss in weight of wood				Average loss in weight for all woods
		Pine	Spruce	Birch	Aspen	
Lenzites sepiaria	35	5.20	5.20	3.50	6.00	4.97
	32	6.60	3.70	3.10	3.20	4.15
	27	3.50	3.90	3.00	3.30	3.43
	22	3.40	3.10	2.20	3.70	3.10
Lentinus tigrinus	35	0.80	2.20	7.10	7.00	4.28
	32	1.60	3.80	5.20	6.80	4.35
	27	3.50	2.00	9.00	10.00	6.12
	22	1.90	0.90	3.40	4.80	2.75
Polystictus versicolor	35	2.00	1.40	7.40	4.80	3.90
	32	2.30	3.60	11.40	8.20	6.38
	27	3.70	3.00	6.70	5.50	4.73
	22	1.30	2.00	3.90	6.00	3.30

aggregate or average loss in weight for all woods will be used as the basis for comparing the rates of decay at different temperatures. It will be seen in table 2, however, that the decay-temperature relationship for any one organism is not consistent for all the woods.

A comparison of figures 1 and 2 indicates a mycelial-growth-temperature and decay-temperature relationship in the case of *Lenzites sepiaria* and *Polystictus versicolor*. Decay caused by these 2 organisms progressed most rapidly at temperatures that were the optimum ones for their mycelial growth on culture media. Thus, the loss in weight produced by *L. sepiaria* was greatest at 35° C. and was successively reduced at each drop in temperature below this point. At 22° C. the average loss in weight due to decay was only 63 per cent of that induced at 35° C. Decay caused by *P. versicolor* progressed at a maximum rate at 32° C. but was fairly rapid at 27° C., also. At 35 and 22° C., the losses in weight were only 61 and 53 per cent of those at 32° C. It is noted in figure 1 that the mycelial growth of this organism was also greatest at 32 and 27° C. and least at 22° C.

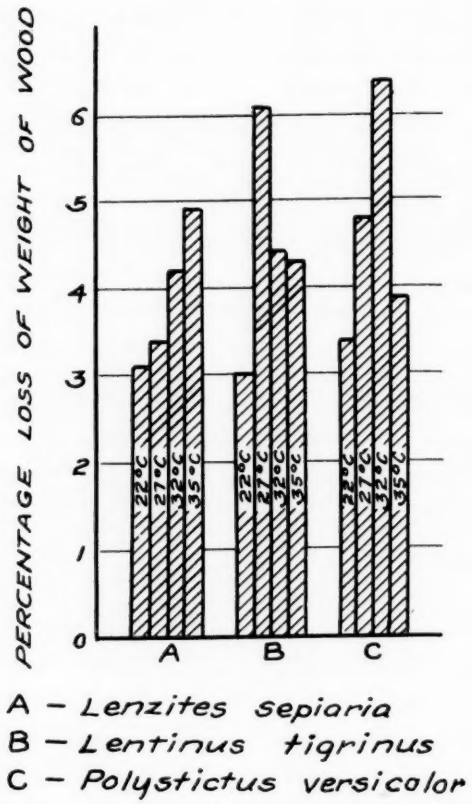

FIG. 2. The aggregate loss in weight of wood induced by *Lenzites sepiaria, Lentinus tigrinus,* and *Polystictus versicolor* under different temperature conditions.

A relationship between rate of decay and mycelial growth at different temperatures was not indicated in the case of *Lentinus tigrinus.* Decay induced by this organism progressed most rapidly at 27° C., while growth of mycelium on culture media was greatest at 35 and 32° C. However, it is seen in table 1 that mycelial growth was fairly rapid at 27° C. as well as at the optimum temperatures. Both decay of wood and mycelial development were materially retarded at a temperature of 22° C.

The 3 fungi varied somewhat in their respective abilities to attack the several woods employed in the decay studies. *Lenzites sepiaria* caused the greatest losses in weight in the 2 coniferous woods, pine and spruce, and was active in decaying birch and aspen, also. *Polystictus versicolor* produced pronounced losses in weight in both of the hardwoods and developed fairly rapidly on the coniferous woods. *Lentinus tigrinus* was distinctly a hardwood-destroying organism, producing decay in birch and aspen equal

to that induced by *P. versicolor* but making little progress in attacking the coniferous woods. Snell (6) reported similar results with *L. tigrinus* and concluded that the rotting potentialities of this organism were limited largely to hardwood timber.

Considering aggregate loss in weight in all temperatures as the criterion of susceptibility to decay, birch proved relatively resistant to *Lenzites sepiaria* but was readily attacked by *Lentinus tigrinus* and *Polystictus versicolor*. Norway pine and white spruce were decayed rather rapidly by *Lenzites sepiaria* but proved more resistant to *Lentinus tigrinus* and *P. versicolor* than either of the hardwood species. These 2 coniferous woods differed little in their relative susceptibility to the several fungi. Aspen was quite readily subject to decay by all 3 organisms.

DISCUSSION

The temperature relations of wood-destroying fungi have been studied on culture media only, probably because this method is the simplest and gives most promise of yielding immediate and consistent results. Since no correlations have been made between the rate of decay of wood and the rate of mycelial growth on culture media at different temperatures, it has been assumed that the temperature relations of an organism on wood could be predicted from the results of tests on agar. In all probability, this assumption is sufficiently correct for all practical purposes, but there are two possible reasons for suspecting that it may not be entirely true. The first concerns the chemical and physical differences between the agar and the wood. It has been demonstrated by a number of investigators that the temperature relations of fungi may vary with the substratum upon which they are grown. Brooks and Cooley (1), for instance, in their study of stone-fruit fungi, found an interesting contrast between the behavior of *Sclerotinia cinerea* (Bon) Wor. and *Rhizopus nigricans* Ehr. when grown at different temperatures on peaches and on potato-dextrose agar, the former organism growing earlier and more rapidly at the lower temperatures on peaches than on agar, while the reverse condition held for Rhizopus. It is conceivable that differences in wood and agar as substrata alter the temperature relations of wood-destroying fungi as well.

The second possible difficulty in predicting the rate of wood decay at various temperatures from tests on agar lies in the time factor involved, agar tests covering relatively short experimentation periods, while decay of wood requires long exposure periods that may continue for years. Fawcett (3) has emphasized the need of considering the influence of time on rate of growth and has shown for certain fungi that growth rates vary for different consecutive observation periods at the same maintained temperature. With

culture periods of from 3 to 6 days and an observation period of 24 hours, it was found for the fungi studied that, in general, the optimum temperature for growth shifted to lower temperatures with each successive observation period and that there was a corresponding displacement of the apparent maximum point. With comparatively low temperatures, the growth rate increased with the age of the culture, and with the highest temperatures it decreased throughout the culture period. If such changes in the growth-temperature relations with different periods of exposure hold true for wood-destroying fungi, tests on agar would indicate the optimum conditions, and possibly the maximum and minimum points, for the initial part of the period of growth in wood only, and a decidedly lower optimum might be expected for decay, continuing through several months and even years. In the present study on agar, there is noted a slight tendency for the growth rate at the higher temperatures to be retarded towards the end of the experimental period, as might be expected from Fawcett's results, but the data are too inconsistent to permit any conclusions. Alhough the results on agar do not indicate definitely that long exposure periods lower the optimum temperature for growth of any of the organisms, it is possible that such a time factor contributed towards the divergence between the results on agar and on wood in the case of *Lentinus tigrinus*.

The work reported in the present paper justifies few definite conclusions because of its preliminary nature and certain irregularities presented in its results. It indicates for the fungi studied that temperatures favorable for mycelial growth are, likewise, conducive to rapid decay, but whether the limits or relative rates of growth are the same on agar and in wood has not been determined. It is hoped that more intensive investigations of these phases of the life history of the more common wood-destroying fungi, possibly using relative losses in weight or the progressive evolution of carbon dioxide as an index of decay, will be stimulated as a result of this report. Such studies will not only contribute to our knowledge of the biology of these organisms but will also have a practical application in the formulation of control practices.

SUMMARY

The effect of temperature on the rate of wood decay and of mycelial growth on culture media was studied under controlled conditions for 3 wood-destroying fungi, *Lenzites sepiaria*, *Polystictus versicolor*, and *Lentinus tigrinus*. The cardinal temperatures for mycelial growth on malt-extract agar were as follows: *Lenzites sepiaria*, optimum 32–35° C., minimum approximately 5° C., and maximum 45° C.; *Lentinus tigrinus*, optimum 32–35° C., minimum approximately 7° C., and maximum 43° C.;

Polystictus versicolor, optimum 27–32° C., minimum approximately 0° C., and maximum 40° C.

Decay caused by *Lenzites sepiaria* and *Polystictus versicolor* progressed most rapidly at those temperatures most favorable for their mycelial growth on culture media. Decay induced by *Lentinus tigrinus* was most rapid at 27° C., while greatest mycelial development occurred at 35 and 32° C. At a temperature of 22° C., decay processes as well as growth of mycelium were materially retarded for all 3 organisms.

Attention is called to the need for correlating tests on agar with decay studies on wood where the temperature relations of wood-destroying fungi are being determined. Mention is made of the differences both in the chemical and physical nature of the substrata and in the duration of fungous development as reasons why predictions of the rate of wood decay at different temperatures on the basis of tests on agar are not reliable.

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TRANSMISSIBILITY OF THE BROOMING DISEASE OF BLACK LOCUST

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In 1898 a witches' broom on black locust, *Robinia pseudacacia* L. was recorded in a brief note by Waters (12). Overlooking this report, Hartley and Haasis (4) recently published a description of a malady that they designated "brooming disease." The two diseases are almost certainly identical. The experimental data in the present paper, though not extensive, combine with field observations to indicate strongly that this locust disease is of the peach-yellows type and is presumably caused by a virus. Particular interest attaches to this disease, partly because it adds to the brief list of viroses of woody plants, which, because of the nature of the hosts, are particularly good material on which to study recovery from virus infections, and partly because it is, to date, the only virus disease that has been described from the rich American forest-tree flora, which includes hundreds of timber-producing species. The parasitic sandalwood, *Santalum album* L., of Asia, is the only other timber tree for which a published report of a virus disease has been noted. Our wild plum, host for peach rosette (11), is scarcely a forest tree in the usual sense of the word.

Histological and cultural studies made thus far have failed to reveal a visible causal organism. The histological technique employed by Heald and Sprague (5) in identifying the fungus associated with the witches' broom of service berry failed to show any trace of a fungus in either the periderm or cortex of the proliferated twigs of black locust. A fungus growing superficially on the bark and tentatively referred to Camarosporium will be described more fully in a later paper. It should be mentioned that Waters reported the same experience with the witches' broom on black locust collected in 1898. J. E. Humphrey thoroughly studied his specimens "and to his surprise found not the slightest trace of fungus hyphae or fructification in or on the tissues. Under the microscope, thin sections showed that the wood was very much gnarled and twisted, and a section through a node resembled somewhat a piece of bird's eye maple. We must, therefore, ascribe the formation of so many adventitious buds and such abnormal foliage to something else than fungus enemies."

Since the brooming disease could not be attributed to the presence of a visible pathogen, the next logical step was to determine the transmissibility of the disease.

TABLE 1.—*Experiments on transmission; grafts made March 16, 1929*

Scions	Source of scions		Graft method	Graft serial number	Scion growth (1929)			Brooming September, 1929
	Branch number	Portion of branch			April 19	May 14	September	
Broomed	1	Terminal	Cleft	1	Slow	Vigorous	Alive	9 in. below graft
	2	Basal	"	2	Fair	"	"	None
	3	Terminal	"	3	Good	"	"	"
	4	"	"	4	1 bud	Poor	Dead	"
	5	Basal	"	5	Good	Good	Tag lost	"
	6	"	"	6	1 bud	Slow	" "	"
	7	Terminal	"	7	Good	Good	Alive	14 in. below graft
	8	"	Veneer	10	None	None	Dead	None
	9	"	"	12	2 leaves	1 leaf	Good	Slight
	10	"	"	14	Sparse	Sparse	Alive	28 in. below graft (Fig. 1)
	11	"	"	16	None	None	Dead	On lateral branch (Fig. 2)
	12	"	"	19	"	"	Good	None
Apparently normal but from broomed branch[a]	7	Basal	Cleft	8	Excellent	Good	Alive	"
	8	"	"	9	None	"	Dead	"
	9	"	"	11	Fair	"	Tag lost	"
	10	"	"	15	None	"	Alive	Mild, to 1 ft. below graft
	11	"	"	17	"	None	Dead	None
	12	"	"	18	1 bud	"	"	"
From normal branch in broomed sprout cluster	13	"	"	20	1 bud	Good	Good	"
	14	"	"	21	Good	"	"	"
	15	"	"	22	Fair	"	"	"
	16	"	"	23	Good	"	"	"
From normal sprout cluster	17	——	"	24	None	None	Dying	"
	18	——	"	25	Good	Good	Good	"
	19	——	"	26	"	"	"	"
	20	——	"	27	"	"	"	"

[a] Taken from 12 in. below lowest broom.

GRAFTING EXPERIMENTS

Normal and diseased scions were top-worked with cleft or veneer grafts on healthy seedling stocks. In the cleft grafts each stock bore 2 scions. The seedling stocks were about 4 years old and had an average height of 3 ft. and diameter less than 1 in. at the time of the grafting. The scions were gathered from several widely separated points in the District of Columbia. The normal scions or checks were cut from sprout clusters that bore no visible evidence of disease history. Each diseased scion was cut from a densely proliferated broom and an apparently normal scion was cut at a distance of approximately 12 in. inwardly on the branch from the last point of visible brooming. The purpose of this second set of normal scions, which was cut from diseased branches, was to determine the systemic distribution of the infective principle. All the scions were dormant and the grafting was done March 16, 1929. Details as to the source and type of scions and their growth are given in table 1.

Of a total of 12 grafts with diseased scions, the scions grew through the summer on at least 7, and 4 of these, together with 1 of those on which the scion had promptly died, showed definite brooming of the stock before the end of the first summer. (See Figs. 1 and 2.) Of a total of 6 grafts with apparently healthy scions from branches that showed diseased terminals, scions were growing 2 months later on 4, and 1 of these developed brooming of the stock. The stocks with lost tags are included among those with no brooming, since, in September, none of the unmarked trees in the planting showed brooms. All of the broomed trees, except that shown in figure 2, were dead the following spring. In each of the 6 cases of positive transmission the brooming symptoms included twig proliferation and leaf dwarfing that are identical with the symptoms observed in the field. Details are presented in table 1.

None of the grafts with scions from normal branches and none of the 39 nongrafted seedlings in the same planting, some in physical contact with the broomed trees, showed any visible brooming symptoms, either in 1929 or the 2 subsequent years. Therefore, it does not appear that the disease is strongly contagious and likely to spread through mere contact or proximity of normal and infected plants.

The apparent lack of need for positive union of the graft and subsequent growth in order to secure transmission, indicated by the single case of Graft 16 (Fig. 2), suggests a dissimilarity with other tree viruses. Graft 16 formed no union and showed no signs of growth, yet the stock developed a definite broom on one of its branches. It has been repeatedly demonstrated that the successful transmission of peach yellows is dependent on a positive union of the grafts (8). In the case of phony disease of peach

[a] Taken from 12 in. below lowest broom.

FIG. 1. Graft 14, showing extent of brooming of the stock 5 months after grafting, as compared with a normal black-locust leaf. Cleft graft at top of trunk.

FIG. 2. Graft 16, showing single terminal branch broom. A veneer graft was made at x, which never formed a union.

(6) normal nursery trees contract the disease when root grafts form a positive union but fail when grafts are negative. Juice injections have failed to transmit such virus diseases as peach yellows, little peach, and spike of sandalwood (9). Nevertheless, in view of the fact that a single scion in these black-locust grafts apparently transmitted the disease without union, it seems logical to attempt juice-injection experiments.

The length of time after grafting required for the appearance on the stock of the symptoms of the disease is in agreement with many virus diseases already reported. In this experiment the black-locust stocks bore well-developed brooms during the same growing season, 5 months after grafting. The grafts were made March 16, 1929, and brooms on the stocks were fully developed by September. This is a short period when compared with that for peach yellows, little peach (Waite, oral communication), and phony disease (6), in which the symptoms do not appear on the stocks till the following season; but longer than for peach rosette (8) and spike of sandalwood (3), in which visible evidence of transmission has been obtained in 2 months. Four months is given as the time required for evidence of transmission through grafts of "buckskin" disease of cherry (7). In the case of witches' broom of ocean spray (*Holodiscus discolor*) (13) the transmitted symptoms are confined to the region of the graft the first season and do not appear in other parts of the plant until the second season. It appears that the length of period from grafting to the development of definite symptoms of the disease on the stock is an important differentiating characteristic of these supposedly virus diseases.

The amount of brooming of the stocks varied from a single terminal broom on a branch (Fig. 2) to complete brooming (Fig. 1). Graft 16 was a particularly interesting case. This graft was previously referred to as one where transmission occurred without apparent union of the graft. A veneer graft was made on the main stem, shown at point (x) in figure 2. Not only did the scion fail to unite, but a bark lesion developed at the wound, which was the apparent cause of the death of the leader 15 months after grafting. The broom appeared terminally on one of the lower branches (Fig. 2). In this case the infective principle had to be transmitted downward through the stem for a distance of approximately 8 in. and then outward to the tip of the branch, which was another 2 ft. This gives a total distance of transmission of approximately 3 ft. No brooming appeared anywhere else on the stock, and during the following 2 years the originally broomed branch has grown normally. For the buckskin graft-infectious disease (7) the greatest distance for transmission from diseased scion to healthy scion during the first 4 months was 2 ft.

The degree of brooming for the other grafts is given in table 1. In general, the outbreak of brooms where transmission was successful was simul-

taneous throughout the entire stock. In nature the brooms commonly occur terminally on sprouts, as shown in figure 2. The simultaneous development of brooming throughout the entire stock, as in figure 1, is another point that closely relates the symptoms of the brooming disease to spike in sandalwood. In transmitting the spike disease from one tree to another through root haustoria (3) the disease appeared simultaneously in all parts of the tree and practically every twig was spiked. The apparent recovery of the locust that showed the least initial symptoms of the disease is in accord with the experience with raspberries (1).

Another important characteristic derived from these transmission data is that the infective principle is actively present and transmissible in the stem and twigs of the black locust. Dissimilarly, the virus causing the phony disease of peach is restricted to the roots and so far it has not been transmitted by means of stem material. In the field it has been observed that locust roots frequently send up completely proliferated sprouts. These broomed sprouts seldom attain a height greater than 18 in. and usually die back at the end of the first growing season, but the same root can give rise to additional broomed sprouts in following seasons. It appears, therefore, that the infective principle is actively present in black-locust roots. So far no attempt has been made to transmit the disease by means of root grafts.

BUDDING EXPERIMENTS

An attempt was made to transmit the brooming disease of black locust by budding. A large number of diseased and normal buds were collected from various field plots in the District of Columbia in late summer, 1929, and budded on to normal seedling stock. None of the buds made union, and the following spring they were all dead. To the end of 1931 none of the budded stocks has shown any visible signs of brooming. The failure of budding may be attributable in part to the morphology of black-locust buds. As shown by Büsgen and Münch (2), the new bud is deeply embedded in the petiole pulvinus. When the petiole is cut off for budding purposes the stub dries up and perhaps hinders the growth and development of the new bud the ensuing spring. The budding method has proved unsuccessful in the experiments with spike of sandalwood (10). The "patch graft" used recently by Sreenivasaya is probably worth trying in future black-locust brooming-disease experiments.

CONCLUSIONS

The brooming disease of black locust has been successfully transmitted in one case to healthy stocks through grafted diseased-stem scions despite the death of the scion. In certain cases the disease failed of transmission despite the union and growth of the scion.

Brooming appeared on the stocks, during the first season, in some cases nearly 3 ft. from the graft. The time requirement for visible evidence of transmission was from 4 to 5 months. One of the infected trees apparently recovered.

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KNOB AND ELEVATED VEIN FORMATIONS ON SWEET-POTATO ROOTS[1]

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There are two specific disorders of the sweet potato that cause the edible root to vary from the normally developed smooth, symmetrical, and uniform shape, denoting quality, to that of an unsightly rough appearance signifying inferior quality. The phenomena are widely distributed in all areas where the crop is grown, but in any area the prevalence is so influenced by such factors as types of soil, amounts of nitrogenous substances in the soil, and precipitation during the growing season that their effects are of no importance in certain seasons and very injurious in others. The slowness in which southern varieties are being accepted in the larger markets is largely a result of inferior quality based mostly on irregular sizes, shapes, and otherwise unattractive appearance displayed because of these two disorders. Studies over a long period of years on the causes of and the factors applicable to inhibiting these two effects are discussed briefly in this article.

THE KNOB CONDITION

The knob disturbance (Fig. 1, A), being of wide occurrence, has made the symptoms well known. Probably every grower of the crop has observed the disorder. The knob character may, without careful examination, be confused with somewhat similar raised areas resulting from infestation by *Caconema radicicola* Cobb, the root-knot forming nema. In potatoes affected with only the knob condition there are no such internal disturbances of the inner tissues as occur after the nema infests the potato and develops in the tissues numerous light-color flask-shape female nemas, encircled by a ring of tissue that becomes oxidized brown in color. Other than displaying an irregular rough outward surface, the potatoes are decidedly normal throughout.

The knobbiness shown in figure 1, A, was obtained by growing the crop on Cecil sandy loam, which, during the drought period of 1930, became very hard. The root during growth gave every evidence of following the lines of least resistance in this soil. Irregular hardness was conspicuous in the soil areas where the roots were developing. The disturbance is always most pronounced on the distal end, the end deepest in the soil. The smaller potatoes as well as the feed roots often show the effects throughout. The

[1] Technical Paper No. 58, North Carolina Agricultural Experiment Station.

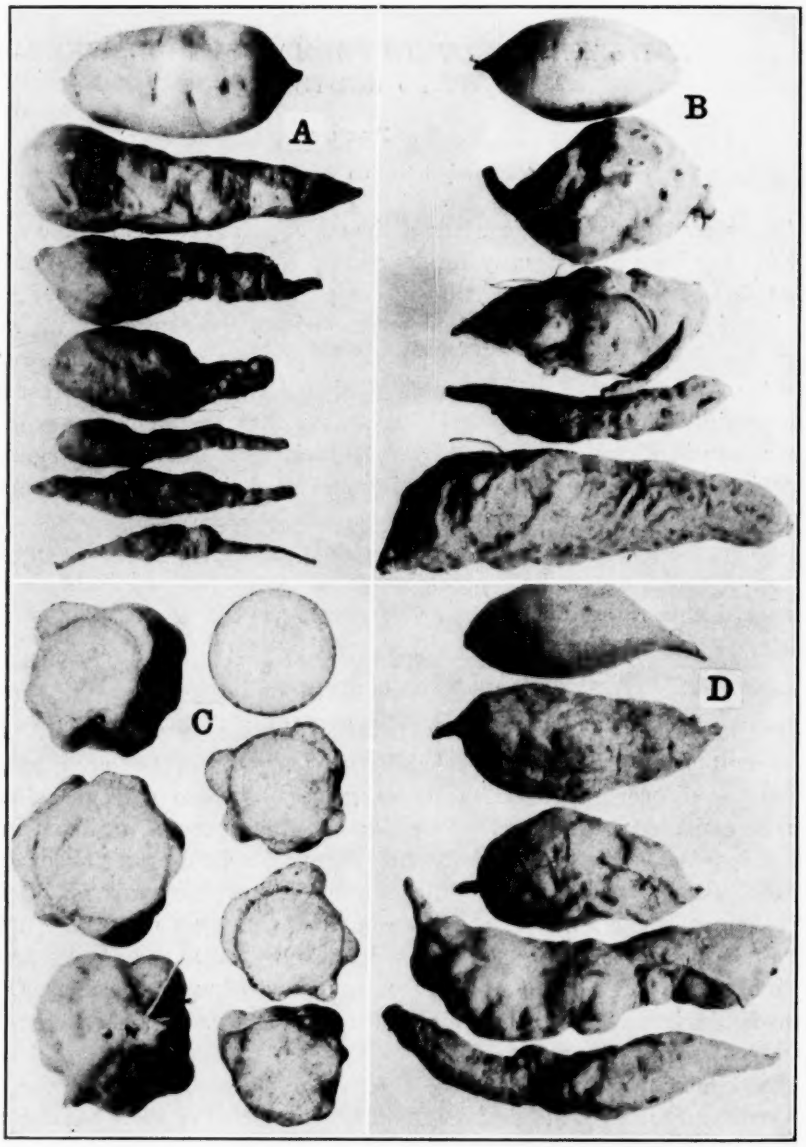

FIG. 1. A–D. Nancy Hall variety of sweet potatoes. A. Comparison of knob disorder on potatoes grown in Durham sandy loam in drought area during 1930 with a smooth symmetrically formed potato grown on loose sandy soil in the same field. B. Vein disorder of potatoes grown on deep phase Durham coarse sandy loam that was dry throughout the latter part of the summer but wet for 3 weeks previous to harvest. C. Cross sections showing the second-growth disorder in comparison with a normal potato. D. Comparison of normal potato with those showing both the knob and elevated vein condition.

crater-like cavities in the small potatoes and the deeper depressions in the larger ones were packed with hard soil when removed from the soil, indicating very great pressure of the root against the hard soil. The epidermal layer, even in the cavities, is not broken; nor is there any evidence that new periderm tissue was formed, such as develops when roots are injured by rodents. It is well demonstrated in the characteristics of the plant that root and potato development will continue regardless of the nature and character of the soil. When soils become compacted and resistant, as the clay and loamy clay soils of the Piedmont areas often do during periods of drought, the feeder roots and potato roots are forced to depart from a straight course of symmetrical development such as obtains in loose soils. When the soil is too hard to be moved readily there will be consequent knobbiness of the potatoes (Fig. 1, A). This characteristic effect is readily developed in pot cultures in clay soil under controlled conditions. During 1930, a drought season, the knob-like formation was most conspicuous on the same area and soils on which it was of no importance in the seasons of 1929 and 1931 when the soil moisture content was more favorable for plant growth and for maintaining less hardness in the soil. The injury in some instances approached complete girdling, but in no instance were any roots found completely divided. It is apparent that the sweet-potato root does not have the power to force hard soils into symmetrical molds but does have a well-developed characteristic of distributing the products in the edible roots, allowing the greatest development in the soft strata of soil. The variation in soil hardness in this area results from irregular depths of plowing soils and from turning under sandy soils when the subsoil is near the surface. Yields on the hard soils are very low, but there is no proof that other intricate factors are not of equal importance in inhibiting growth. Low soil moisture alone influences the plant to root deeply and profusely when the leaf area is large. The knob effects become very noticeable in seasons when there is an abundance of moisture during the early development of the roots, and when followed by a long period of soil-moisture deficiency, which causes the upper strata to become dry and hard. The Norfolk, Durham, and Granville sandy soils of a deep phase rarely produce the knob effect.

THE SECOND-GROWTH AND VEIN CONDITION

The potatoes shown in figures 2 and 1, B and C, have developed second growth characterized by raised vein-like markings. This condition occurs in small, large, short, and long potatoes alike. The sizes of the veins are well illustrated in figure 1, B, and in cross sections of some of the potatoes shown in figure 1, C. Some of the smaller veins are barely raised, noted only by the vein outline. Others vary in depth up to an inch in diameter.

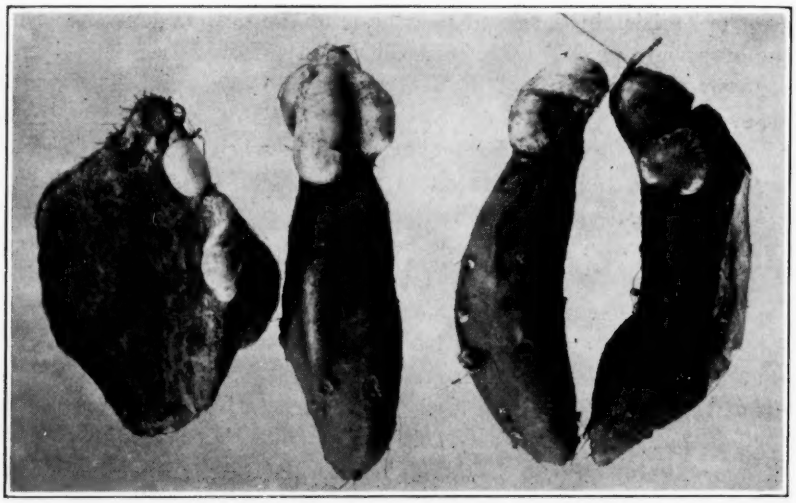

FIG. 2. Old mother potatoes producing second growth after having produced a crop of plants.

The primary cambium was permitted to oxidize sufficiently before making the photograph of figure 1, C, so as to bring out clearly and to distinguish the second-growth characters. New cambium is formed in the second growth; however, it is not clearly shown in the figure. Microscopical examination of the second-growth tissues does not indicate anything peculiarly different from that of the first growth. The edible qualities are not impaired at any time and the keeping qualities, as measured by desiccation and attacks of fungi while in storage, are just as good as those not affected by the vein condition.

A number of factors, fluctuations in soil moisture being the most important, cause second growth, but the cause of the phenomenon of vein formation is unknown. The inconsistency with which these veins occur on all sides of the potato confuses any theories set forth that veins arise from any definite sort of cells or tissues. The second-growth condition develops most prominently when low soil moisture prevails during the early development of the edible root and when this condition is followed by high soil-moisture content during the latter stages of development. The exact period of time that each condition must prevail to produce the effect is not known. Studies conducted in pots under controlled conditions have been unsatisfactory because of smallness and irregularity in shape of the potatoes.

Fertile soils, heavy nitrogenous fertilization, and such organic materials as barnyard manure and legume débris are definite aids to second growth. With sufficient soil moisture available for optimum growing conditions,

these substances force the plant to develop rank vines, on which the potatoes react suddenly to moisture conditions toward the latter part of the season.

All of the important commercial varieties are subject to second growth, but the Norton Yam and Nancy Hall varieties develop more prominently this condition than do the varieties Porto Rico and Jersey. The Big Stem Jersey strains also develop the vein more consistently than do the strains that produce smaller potatoes. The large and oldest potatoes develop the vein condition more consistently than do smaller potatoes, even on the same plant, but this does not account for the difference in susceptibility, since the variety Porto Rico, which is somewhat resistant, produces larger potatoes than does the more susceptible Nancy Hall variety. The second-growth character has been produced also on the stem of Vineless Yellow Jersey when plants are left attached to the mother potato throughout the summer in potted sand cultures (Fig. 3).

FIG. 3. Vineless Yellow Jersey potato kept in sand throughout the summer, showing plants with a well-developed second-growth condition on the stem.

DISCUSSION

The knob and elevated vein disorders may both occur on the same potatoes (Fig. 1, D). The hard soils may even influence the size of the elevated veins.

In sweet-potato culture it is well known that the development of the vines and leaf area can be advanced to such a degree that carbohydrate

development, at least that expressed by the formation of the edible root, is inhibited and delayed. The exact amount of leaf area necessary to develop the optimum quality of marketable edible roots probably varies extensively because of marked variations of growth and yields for different growing seasons. However, information on the fertilization of the crop points the way for greater uniformity of quality in the future. The use of recommended formulas of a definite analysis is open to some criticism in that there is lacking in the recommendations the necessary definite information on how and when to apply them scientifically to complex sandy soils containing a variable supply of available elements necessary for plant growth but to which the crop is most practically adapted. The sandy soils are mechanically well suited to sweet-potato development, but the character of growth and yields obtained without any other evidence shows that these soils are of the most irregular sort in maintaining the elements necessary to the growth of the plant. Even with all such factors beyond the possibility of immediate control, marked improvement in quality can be obtained and such disorders as are described here may be essentially eliminated by growing adapted varieties on well-drained sandy soils, exercizing caution with applications of nitrogenous fertilizers but with liberal applications of potassium-supplying substances.

SUMMARY

Sweet potatoes in all areas where grown are subject to 2 distinct nonpathological conditions that do not prejudice their edibility but do seriously affect their marketable quality.

The names of the conditions are referred to here as knob and vein disorders or formations.

The knob condition is easily differentiated from knots formed by *Caconema radicicola* infestation, by the absence of the oxidized brown tissues developed when caused by the latter. The knobbiness results in hard soil formed during drought periods, in which the growth of the potato is greatest in the looser soils.

The cause of the vein phenomenon is not known, but it is a result of second growth of the roots in soils of high moisture content, especially when preceded by drought conditions, and its development is aided by loamy soil types, nitrogenous fertilizers, barnyard manure, and leguminous débris.

The use of well-drained sandy soils that are adapted to the particular variety and the exercise of caution in the use of large amounts of nitrogenous fertilizers are advanced as control practices.

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CROWN GALL ON A CONIFER

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Cupressus arizonica Greene is a conifer native to Arizona. The tree is a valued ornamental in the Southwest because it grows as well on the mesa and in valleys as it does in a wild state on mountain slopes in its native habitat. Another quality that makes this species valuable is its resistance to Texas root rot (*Phymatotrichum omnivorum* (Shear) Duggar) which annually kills many shade and ornamental trees at the lower altitudes in southern Arizona.

A small grove of *Cupressus arizonica* (Fig. 1, F) on the campus of the University of Arizona contains individual trees that have attained a height of 40 ft. or more. The trees are growing in filled ground underlaid with caliche. Some months ago several trees in the grove showed dead tips, and, after examination by entomologists, they were declared infested with the engraver beetle, *Phloeosinus cristatus* Le Conte.[1] The infested trees were cut down and the stumps excavated. Most of the work of removing the trees was done before our attention was directed to the roots of a tree that showed numerous galls (Fig. 1, I).

The galls on the cypress superficially resembled crown galls (Fig. 1, D, C, G, H). Their surfaces were more or less rough. In size they varied from slight swellings to tumors 6 to 9 in. in diameter. One of the larger galls, but not the largest by any means, weighed 1,395 gm.

In texture most of the galls were hard, but a few spongy ones were found. The hard galls consisted of both concentric and eccentric thickenings produced by increased local activity of phellogen and cambium. Tracheids, which, of course, make up almost the entire mass of the xylem, showed transverse, oblique, and longitudinal aspects in the same cross section of a gall (Fig. 1, J). In general, the tracheids were normal in appearance. However, in some small protuberances on the surface of large galls the tracheids developed tangentially with reference to the axis of the protuberance, presented a whorled appearance, and the innermost ones were abnormally enlarged. The xylem showed growth rings, which were irregular in thickness (Fig. 1, A). In some roots sections through galls showed that the original stele at the time the gall started had partly decayed (Fig. 1, A).

[1] Vorhies, Charles T. Destroy infected cypresses. Arizona Producer (Phoenix) 9: (11): 8. Aug. 15, 1930.

FIG. 1. Crown gall of *Cupressus arizonica*. A. Cross section of gall on partly decayed root. B. Gall resulting from needle inoculation with causal Bacterium on petiole of *Ricinus communis*. C, D, G, and H. Enlarged galls from I. E. Cross section of a healthy root. F. *Cupressus arizonica* on campus of University of Arizona. I. Crown galls outlined with cotton wool, on roots of *C. arizonica*. J. Photomicrograph of part of cross section of a gall. Note vertical, oblique, and longitudinal aspects of tracheids.

The cortex was thicker than that of normal roots and from its outer surface an abnormal sloughing-off of dead cells occurred. Living cortical cells frequently contained a resinous mass of material. The cambial zone was generally much wider in sections of the galls than in sections of normal roots, and the phloem was likewise enlarged.

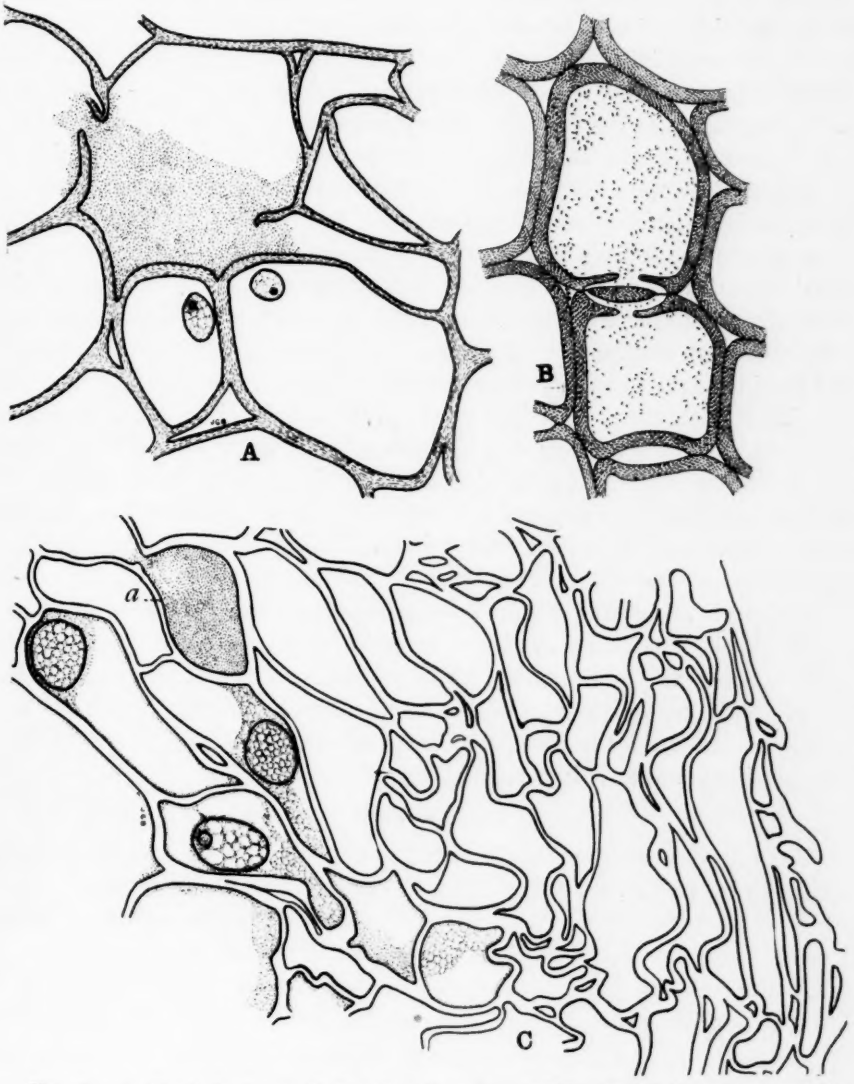

FIG. 2. A. Bacteria in cortical cells of root. ×1,088. B. Bacteria in tracheids. ×1,088. C. Part of a cross section of a gall showing cortical and subcortical cells. Bacteria in a medullary ray cell at *a*. ×554.

Living cells of the galls, as shown by stained sections, contained nuclei somewhat larger than those of normal cells in comparable tissues. No binucleate cells were found. Less starch was present in the gall cells than in similar cells of healthy roots.

Although no fungal parasites were found, either in stained microscope sections or in cultures of the gall tissues, bacteria were abundant in both. In the stained sections bacteria appeared not only in cells of the cortex but also in the cambial region and even in the tracheids (Fig. 2, B). It is probable that at least some, possibly all, of these bacterial masses represented saprophytic forms or secondary invaders. The location *inside* the cells suggests a tissue-destroying rather than a gall-producing organism.

Inoculations were made on Patel's medium[2] from gall tissues after the usual surface sterilization of the galls with 1:1000 mercuric chloride solution. From the inoculations there was isolated a motile bacterium whose physiological reactions on common laboratory media corresponded with those described for *Phytomonas tumefaciens* (Sm. and Town.) Duggar. This bacterium was inoculated into growing tissues of *Ricinus communis* L. and the inoculations were paralleled with the proper controls. It was also inoculated into many seedlings of *Cupressus arizonica*. The inoculated plants of the castor bean gave small galls (Fig. 1, B) from which the original bacterium, only, was reisolated. Even in the needle punctures in Ricinus that failed to respond to inoculation by gall production, the bacterium remained alive and was reisolated after considerable time had elapsed, in one case after 12 weeks.

Although all seedlings of *Cupressus arizonica* were grown in steam-sterilized soil, the first lot was lost through damping-off. Undue enthusiasm on the part of the investigators led to premature inoculation of the second lot of seedlings, which were killed by the needle wounds in crowns and taproots. A third lot is growing at the present time in which some seedlings are showing small swellings.

DISCUSSION

Tumors of a resinous nature on the conifers, *Pinus sylvestris* L., *P. laricio* Poir., and *P. maritima* Mill., are referred to by Dufrénoy.[3] They occurred on aerial members. Neither the tumors nor the causal organism, a coccus, agrees with the galls and the bacterium herein described.

At the time this paper on the galls of *Cupressus arizonica* was prepared for presentation at the New Orleans meeting of the American Association

[2] Patel, M. K. An improved method of isolating *Pseudomonas tumefaciens* Sm. and Town. Phytopath. **16**: 577. 1926.

[3] Dufrénoy, Jean. Sur les tumeurs bactériennes expérimentales des pins. Compt. Rend. Acad. Sci., [Paris] **169**: 545–547. 1919.

for the Advancement of Science[4] no account of crown gall on a conifer was discovered in literature by the writers. Since that time Miles and Brown[5] have reported crown gall on *Juniperus sabina* L. No inoculation studies are mentioned.

That crown gall is uncommon on the Arizona cypress seems to be true, since the senior writer has lived in Arizona for more than 22 years, has been frequently called upon to examine trees that were not doing well, and has never before observed crown gall in this species, although the disease is very common on shade trees and ornamentals. On the other hand, the Arizona cypress has been planted extensively in the cities and towns of southern Arizona only in recent years; furthermore, the occasional death of a tree, even in a country where trees are highly valued, may pass without comment or notice to plant pathologists. Again, it is possible that crown gall develops slowly on the cypress when the tree is growing in deep, fertile soil, although under similar favorable conditions for the growth of the host the disease is fatal in Arizona in a very high percentage of cases involving certain other species of trees.[6] Probably the sclerophyllous nature of the foliage of *Cupressus arizonica* and possibly also its root habit, in their relation to transpiration, favorably affect the longevity of the host.

SUMMARY

Crown gall on the roots of *Cupressus arizonica*, believed to be the first reported case of the disease on a conifer, is described with respect to the nature of the galls, the reaction of the bacterium on culture media, and the result of cross inoculations into *Ricinus communis*.

UNIVERSITY OF ARIZONA,
TUCSON, ARIZONA.

[4] Brown, J. G. Crown-gall-like hypertrophies on a conifer. (Abst.) Phytopath. 22: 1932.

[5] U. S. Dept. Agr., Bur. Plant Indust. Pl. Dis. Reptr. Sup. 81; 133. 1931.

[6] Dorsey, M. J. Crown gall from the horticulturists' viewpoint. 8 pp. *In* The crown gall resolution. 41 pp. unno. Amer. Assoc. Nurserymen: Louisiana, Missouri. 1924.

PHYTOPATHOLOGICAL NOTES

The Bulbous Irises as Hosts of Tylenchus dipsaci, the Bulb or Stem Nema.—The earliest and, to our knowledge, the only literature records of bulbous iris attacked by *Tylenchus dipsaci* Kühn, are two notes by Ritzema Bos in 1925[1] and 1926,[2] both manifestly referring to the same material. Our earliest records go back to 1928, when this pest was observed almost simultaneously on iris bulbs imported from Holland and from a planting on Arlington Farm, Virginia.

A summary of our observations follows: In the period from the fall of 1928 to July, 1932, 38 lots of bulbous irises were found infested with *Tylenchus dipsaci*. Of these, 23 were foreign (Canada, England, France, and Holland) and 15 were domestic-grown (Florida, North Carolina, Oregon, South Carolina, Virginia, Washington, and Wisconsin, but mostly of foreign origin). These lots included 22 different varieties belonging to Spanish (*Iris xiphium* L.), Dutch (*I. xiphium hybridum*), English (*I. xiphioides* Ehrb.) and Morocco iris (*I. tingitana* Boiss. and Reut.).

The disease symptoms appear to be the same or very similar in all four of the species. To recognize young infections, the brown outer scales of a bulb should usually be removed. Contrary to the development in narcissus and hyacinth bulbs, where an infection usually works down into the bulb from the neck region, in bulbous irises it commonly starts from the

FIG. 1. Early stage of a *Tylenchus dipsaci* infestation of English iris. Exterior view shows typical spots (yellowish); cross section of the same bulb shows the infestation as small circular spots.

[1] Ritzema Bos, I. *In* Verslag over de werkzaamheden van den Plantenziektenkundigen Dienst over het Jaar 1924. Verslag. en Meded. Plantenziektenkund. Dienst Wageningen, no. 41: 16. 1925.

[2] Ritzema Bos, I. Het stengelaaltje in Iris. Tijdschr. Plantenziekten. 32: 199. 1926.

side surface, where it first shows up as a yellow spot or streak. As it spreads out, its center turns brown, even grayish, changing to a lead color (Figs. 1 and 2, A). The center of the affected area may now appear faintly

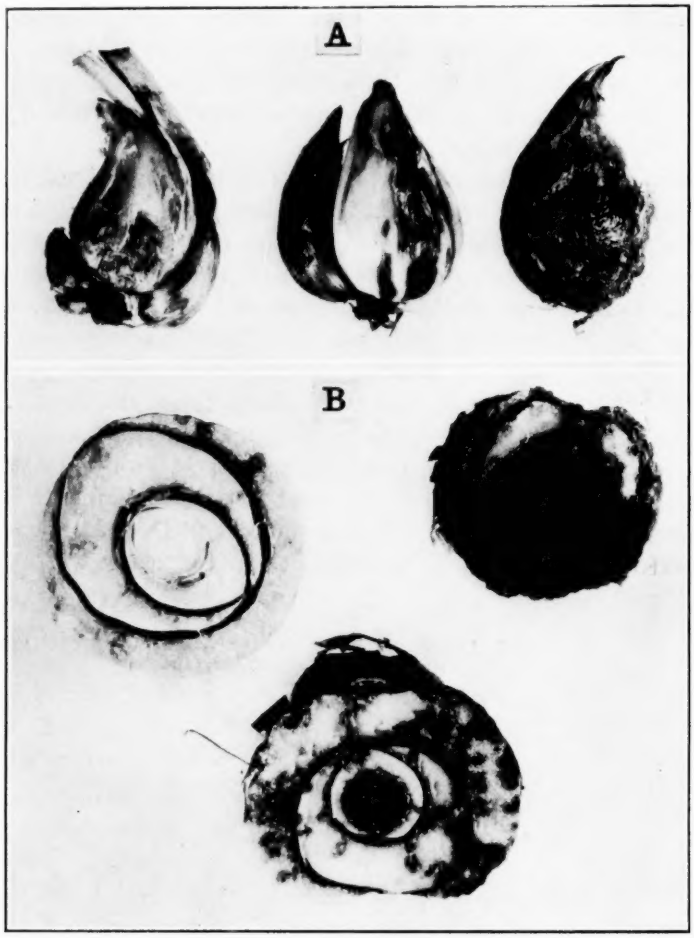

FIG. 2. A. Exterior view of various stages of *Tylenchus dipsaci* infestation of English iris bulbs. B. Cross sections of various stages. Black rings are shadows between scales and should not be confused with infected areas. Photographs through the courtesy of Dr. F. Weiss, Division of Horticultural Crops and Diseases, U. S. Department of Agriculture.

sunken, whereas in earlier stages it is sometimes slightly elevated. A cross section through the bulb at an early stage of the disease shows the infections as circular areas (Fig. 1).

If more than one original infection spot or streak is present, they may flow together as the disease progresses. Gradually the whole scale turns spongy, and is then often quite distinctly set off from the rest of the bulb. In still more advanced cases the whole bulb may be affected; the lead-color areas flow together, and small tunnels or canals may be seen with the aid of a hand lens (Fig. 2, B). Soon, decay will set in.

As far as is known, these symptoms are restricted to the bulb proper. The green parts of an infested plant exhibit no "spikkles," thus differing from the narcissus. The leaves remain backward in growth and sometimes become yellowish. Specimens of *Tylenchus dipsaci* rarely are found in the leaves. No flowers develop except when the disease is still in its earliest stages. If the pest is not checked, 5 or 6 months' time seems to suffice to kill a bulb.

Experiments attempting the transfer of *Tylenchus dipsaci* from bulbous irises (on a small scale and under greenhouse conditions) to narcissus and onions were not successful.

As a control measure a hot-water treatment, similar to that for narcissus bulbs, was tried, but no conclusive results have yet been reached. It is probable that the infestation may be controlled by a hot-water treatment, but its effect upon the iris plant itself has not been satisfactory.

It may be mentioned here that, recently, *Aphelenchoides fragariae* (Ritzema Bos) (= *Aphelenchus subtenuis* (Cobb)) has also been observed attacking iris bulbs. The symptoms seem to be the same as those described above for *Tylenchus dipsaci*.—G. STEINER and EDNA M. BUHRER, Division of Nematology, U. S. Department of Agriculture, Washington, D. C.

Field Inoculations of Pinus strobus with Sporidia of Cronartium ribicola in Minnesota.[1]—In the summer of 1927 a number of field inoculations were made with sporidia of *Cronartium ribicola* Fischer on 3 to 7-year-old *Pinus strobus* L. trees growing naturally in 2 different localities in Minnesota. The inoculating material consisted of telium-bearing leaves obtained from 2 host species, *Ribes nigrum* L. and *R. cynosbati* (L.) Mill. The purpose of this work was to determine whether pine could be inoculated successfully in the field. This paper reports the successful production of infection in pine, growing naturally, and suggests a possible difference in virulence of the sporidia from the 2 Ribes host plants.

The methods used were essentially the same as those reported by Snell and Gravatt.[2] Telium-bearing leaves of approximately the same age were

[1] Paper No. 1086 of the Journal Series of the Minnesota Agricultural Experiment Station.

[2] Snell, W. H., and Annie Rathbun-Gravatt. Inoculation of *Pinus strobus* trees with sporidia of *Cronartium ribicola*. Phytopath. 15: 584–590. 1925.

carefully selected from bushes of *Ribes nigrum* and *R. cynosbati* growing in Duluth, Minnesota, and were kept in an ice box for 24 hours before use. The leaves were cut into small pieces and placed in Petri-dish moist chambers for a period of 8 hours to induce germination of the teliospores. An examination of material from both Ribes species showed abundant teliospore germination within that period. Pines, ranging in age from 3 to 7 years and growing under natural conditions in areas near Afton and Rush Lake, Minnesota, from which the Ribes had been eradicated a number of years before, were selected for inoculation. Although native Ribes had returned to these areas to some extent, no natural infection was found on either host in the region of the inoculation studies. The plants were thoroughly sprayed with water before and after the inoculum was applied. Approximately the same number of branches were inoculated at the 2 areas, inoculation being accomplished by fastening pieces of telium-bearing Ribes leaves to clusters of pine needles by wire hairpins. No effort was made to insure equal chances of infection of the pine on the 2 areas through using the same quantities of sporidia as inoculum, other than that of applying approximately the same number of leaf pieces of uniform size to each plant. The modified "iceless-refrigerator" method adopted by Snell and Gravatt for use in covering the plants was not employed in this study. Instead, wet sphagnum moss was heaped around the base of each pine and the entire plant covered by a large can, 18 in. high, over and around which wet burlap sacks and moss were placed. This type of refrigeration proved very effective in maintaining the necessary high humidity and relatively low constant temperatures around the plant during the incubation period. Droplets of water still remained on the needles 48 hours after inoculation, when the cans were removed. Maximum and minimum thermometers kept inside the moist chambers during incubation showed temperatures of 76 and 57° F., respectively.

The first examination of the pines was not made until November, 1929, 2 years and 3 months after inoculation. The results of this inspection are given in table 1.

TABLE 1.—*Results of inoculating small Pinus strobus trees in situ with sporidia of Cronartium ribicola*

Test location	Age of trees	Source of inoculum	Inoculated trees			Uninoculated trees	
			Number	Number infected	Branches infected	Number	Number infected
Rush Lake, Minn.	3–7 yr.	*Ribes nigrum*	9	8	23	2	0
Afton, Minn.	5–7 yr.	*Ribes cynosbati*	9	1	1	2	0

All trees classified as infected had one or several of the definite external symptoms of infection, such as swelling and discoloring of the stem, killing of the twigs and branches, and, in some cases, perceptible stunting of growth. The unavoidably long interval between inoculation of the pine and first examination precluded any determination of whether or not such early evidences of infection as yellow spots in the needles appeared. No pycnia or aecia had been produced on any of the plants. York *et al.*[3] found in their field studies that only a small percentage of the infections had produced pycnia or aecia 3 years after inoculation.

Of the 9 trees inoculated with sporidia from *Ribes nigrum* at Rush Lake, Minnesota, 8, or 89 per cent, of them showed definite symptoms of infection. On 2 of the diseased plants only single branch infections occurred, but in the others cankers had developed on from 3 to all of the branches of the tree. At Afton, where the source of inoculum was *R. cynosbati* instead of *R. nigrum*, only 1 of the 9 inoculated trees became infected. All non-inoculated plants, which had been kept under moist chambers and were intended to serve as controls, remained free from infection.

In examining the results of these field inoculations, the question arises as to an explanation for the pronounced difference in the amount of infection obtained in the 2 localities. Conditions subsequent to inoculations were more favorable for infection of the pines at Rush Lake than at Afton. Since little effort was made to insure equal chances of infection by using the same quantities of sporidia, there existed a possible difference in the amount of inoculum provided. Although either or both of these variables, weather and the amount of inoculum, might explain the difference in results, it seems reasonable to suggest that differences in the virulence of the sporidia of the 2 Ribes hosts might have been involved. York *et al.* report some evidence of a relation between the source of inoculum and the amount of infection produced but are doubtful whether such results indicate a difference in virulence or merely in number of the sporidia. They suggest that, if the amount of inoculum on the different Ribes species used in their study was the same, bushes of all species would be equally dangerous to near-by pines. While the differences here reported might be ascribed wholly to some similar cause, it appears that the problem of possible variations in the potency of sporidia from different sources would be worthy of careful investigation.—RALPH M. LINDGREN and A. DALE CHAPMAN, University Farm, St. Paul, Minnesota.

[3] York, H. H., W. H. Snell, and Annie Rathbun-Gravatt. The results of inoculating *Pinus strobus* with the sporidia of *Cronartium ribicola*. Jour. Agr. Res. **34**: 497–510. 1927.

A Disease of Colorado Fir.—In the spring of 1931, a disease attacking the new growth of a number of Colorado firs, *Abies concolor,* was conspicuous in a planting of about 500 trees in eastern Massachusetts. From a distance the trees appeared as though injured by late frosts. The needles of the new growth were affected before they reached maturity. They became reddish and shriveled, then dark brown or black. A considerable number of the dried needles clung to the twigs for some time, but by midsummer a second growth of stunted or malformed needles had taken the place of some of the infected ones. In a number of cases, the twigs bearing the shriveled needles were blackened, stunted, and slightly twisted or curved. On such twigs a second growth of needles was not produced. Although needles on all parts of the trees were infected, the new growth on the lower branches appeared to be most severely injured. The diseased needles showed an abundance of fruiting bodies protruding from both surfaces, but no spores were present.

In March, 1932, it was found that a number of the brown needles had overwintered on the twigs and that fruiting bodies were visible. An examination of this material showed excellent mature perithecia and spores. In the late spring the affected trees had developed new growth from the noninfected portions and from those twigs that were not seriously injured in 1931. The new growth, however, soon began to show yellow infection spots or entirely yellowed leaves. Infection seemed to occur particularly on the new leaves that were in contact with or in close proximity to the perithecia-bearing leaves of last year's growth.

Causal organism. The fungus on the overwintered leaves corresponds with the description of *Rehmiellopsis bohemica* Bub. and Kab., reported as causing serious injury to silver fir, *Abies pectinata,* by Bubak in Bohemia[1] and by Wilson and MacDonald in Scotland.[2] Wilson stated that, because of the disease, the planting of silver fir in Scotland had been discontinued to a large extent. He reported the disease also on *A. nobilis, A. Pinsapo, A. cephalonica,* and *A. Pindrow.* Boyce,[3] in a report of his observations of the disease in Scotland, in 1925, called attention to the fact that the only American species attacked was noble fir, *A. nobilis.*

The perithecia are single, globose, slightly conical at the upper part, and opening irregularly by the rupture of a mass of cells in the conical portion. The asci, which extrude in fascicles, are large, about 69×17 μ, clavate, with

[1] Bubak, F. Zwei neue, Tannennadeln bewohnende Pilze. Naturw. Ztschr. Forst- u. Landw. **8**: 313–320. 1910.

[2] Wilson, M., and J. MacDonald. A new disease of the silver firs in Scotland. Trans. Roy. Scot. Arbor Soc. **38**: 114–118. 1924.

[3] Boyce, J. S. Observations on forest pathology in Great Britain and Denmark. Phytopath. **17**: 1–18. 1927.

thick walls, and a short stalk. The spores measure about 24×7 μ, are bicellular, 10 or more in an ascus, irregularly arranged, hyaline, rounded at the upper end and acute at the lower; the upper cell is broader than the lower. Paraphyses absent. No pycnidial stage has been definitely identified in the material collected. Bubak and Wilson report a pycnidial form, produced soon after infection, which they name *Phoma bohemica*. A corresponding fungus has not yet been obtained from either specimens or cultures.

Sections through the blackened twigs bearing diseased needles collected in the spring show mycelium in abundance in the leaf cushions. The hyphae gradually advance inward between the cells of the twig, being preceded by a brownish discoloration of the cell walls, a pronounced thickening of the walls and distortion of the cells, and an abnormal production of resin.

So far as known, this is the first report of the occurrence of *Rehmiellopsis bohemica* in the United States and also the first report of *Abies concolor* as a host. A similar disease has been found by the junior writer on *A. concolor* in Maine, and specimens of the disease on an unidentified species of fir were received from a correspondent in New York.

Bubak found that the young growth injured by spring frosts was most susceptible to infection. Observations in the spring of 1932 showed particularly that the Colorado firs had not been injured by frosts but were severely infected.—ALMA M. WATERMAN and MALCOLM A. MCKENZIE, Division of Forest Pathology, Bureau of Plant Industry, in cooperation with Department of Botany, Brown University.

Disease Resistance in Allium fistulosum L.—The onion variety Winterhecke, which Anderson[1] [2] found to be highly resistant to *Urocystis cepulae* Frost, has been identified by L. H. Bailey as *Allium fistulosum* L., a species reported by Zillig[3] and Anderson[2] as rather highly susceptible to smut. The Winterhecke is synonymous with the White Welsh (Ciboule blanche hâtive or Ciboule d'hiver) and very similar to the varieties Natsu-negi Nebuka, Senju-negi Nebuka, Tokyo Nebuka, and Iwatsuki, all of which belong to the same species and are highly smut-resistant. Although, under favorable conditions, smut infection in these varieties frequently averaged 10 to 20 per cent in the cotyledonous stage, it always fell to $\frac{1}{2}$ or less per cent in later counts.

[1] Anderson, P. J. Susceptibility of species of Allium to onion smut. (Abst.) Phytopath. **14**: 26. 1924.

[2] Anderson, P. J. Comparative susceptibility of varieties of onions and species of Allium to Urocystis cepulae. Jour. Agr. Res. **31**: 275–286. 1925.

[3] Zillig, H. Unsere heutigen Kenntnisse vom Zwiebelbrand (Tuburcinia [Urocystis] cepulae [Frost] Liro) und seiner Bekämpfung. Centbl. Bakt. II, **60**: 50–58. 1923.

Another strain of *Allium fistulosum*, received under the name *A. Moly* and characterized by the production of only 2 to 3 leaves, growing at angles of about 45 to 70°, proved more susceptible to smut (45 per cent), thus supporting Anderson's finding that varying degrees of smut resistance exist in *A. fistulosum*.

The Winterhecke, White Welsh, and Nebuka strains possessed a much more vigorous root system and notably less pink root, caused by *Phoma terrestris* Hansen, than nongreen varieties, approaching maturity. The first also showed a seeming degree of resistance to mildew, *Peronospora schleideni* Unger, in that infections were confined to relatively small local areas and did not spread readily over the entire leaf surface.

Allium fistulosum is a green, hardy, bulbless onion with much variation in color of stem, being either red, yellow, or white, or all three. It is distinguished from *A. cepa* L. by the absence of lobes or teeth at the bases of the 3 interior filaments.—E. L. FELIX, A. A. Grinnell Co., Inc., and Porter & Bonney Farms Laboratory, Elba, N. Y.